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PHYSICS ABSTRACTS

SECTION A

of

SCIENCE ABSTRACTS

SECTION A, PHYSICS

SECTION B, ELECTRICAL ENGINEERING

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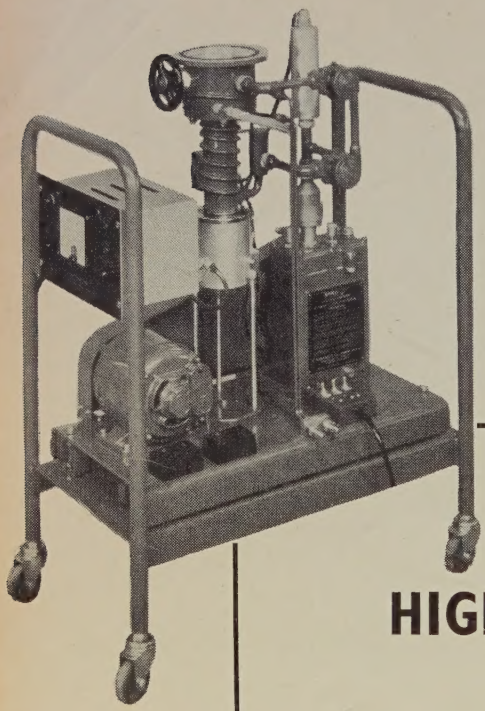

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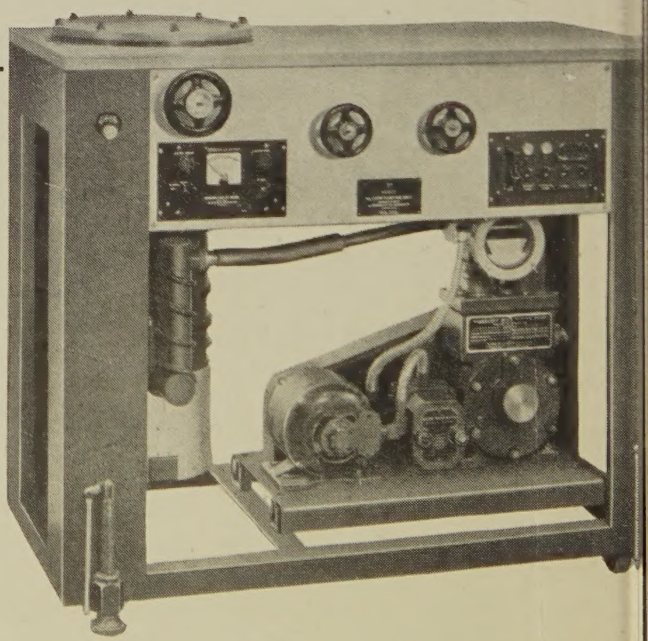

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RELATED SUBJECTS CONTAINED IN SECTION B (ELECTRICAL ENGINEERING ABSTRACTS)

Electrical and magnetic measurements and instruments
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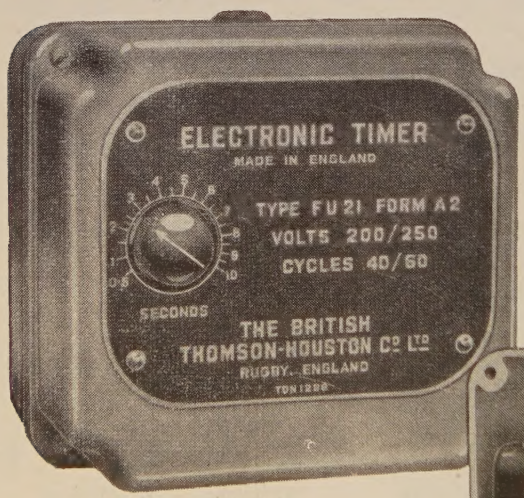

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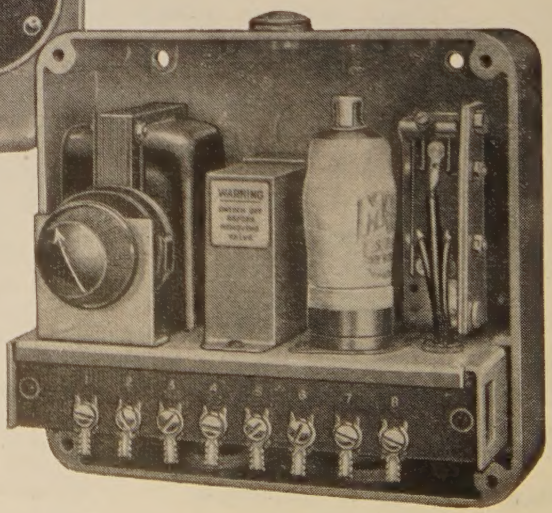

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MATHEMATICS 51

512.94

8436. The application of certain linear quaternion functions of quaternions to tensor analysis. C. W. KILMISTER. *Proc. Roy. Irish Acad. A*, **57**, *No.* 4, 37–52 (*April*, 1955).

Some preliminary results in quaternion theory are stated, and some new results on singular linear functions are derived. Quaternions are linked with special relativity theory, and the results of Whittaker and of Puse [Abstr. 1 (1948)] connecting six-vectors and spinors are generalized. L. S. GODDARD

517.942.922

8437. Solution of an equation associated with the Bessel equation. R. SERVRANCKX. *Bull. Acad. Roy. Belgique Cl. Sci.*, **41**, *No.* 5, 556–9 (1955) In French.

The study of the electromagnetic field in a type of accelerator leads to an equation [Abstr. 8023 (1955)] which is here solved in the form of an infinite series, involving Bessel functions. For certain values of the parameters involved the solution has a finite form. L. S. GODDARD

518.5

8438. An attempt to simplify coding for the Manchester electronic computer. R. A. BROOKER. *Brit. J. appl. Phys.*, **6**, *No.* 9, 307–11 (*Sept.*, 1955).

Outlines some of the difficulties encountered in attempting to simplify the task of preparing programmes for a large-scale digital computer. In general this is most simply achieved at the price of increasing the machine time consumed by the resulting programme. Such a compromise is nevertheless worthwhile for many "small" problems and a means is described for treating such problems on the Manchester University Computer (Ferranti MK I computer). The method is also applicable to any of the Ferranti range of machines, several of which are now available in this country. A.

518.5 : 530.145

8439. An audio-frequency circuit model of the one-dimensional Schroedinger equation and its sources of error. J. H. BLACKWELL, D. R. FEWER, L. J. ALLEN AND R. S. CASS. *Canad. J. Phys.*, **33**, *No.* 8, 483–91 (*Aug.*, 1955).

An audio-frequency circuit model of the one-dimensional Schrödinger equation has been constructed, based on original suggestions by G. Kron. The previous theory of such devices has been re-examined thoroughly and errors due to the basic finite-difference approximation separated from those due to electrical causes. It is found that the former type of error is likely to be dominant in practice and that in the past discrepancies due to errors of this kind have actually been ascribed to experimental causes. A.

518.5 : 621.398 : 681.142

8440. A magslip isograph. G. M. PARKER AND R. W. WILLIAMS. *J. sci. Instrum.*, **32**, *No.* 9, 332–5 (*Sept.*, 1955).

An isograph is described in which the terms of the polynomial equation to be solved are represented by alternating voltages of varying time phase obtained from magslip transmitters in association with resistance potentiometers. The application of this principle results in a compact machine capable of finding roots with good accuracy. The isograph may also be used for the evaluation of polynomials. A.

519.2

8441. The sampling distributions of statistics derived from the multivariate *t*-distribution. E. A. CORNISH. *Austral. J. Phys.*, **8**, *No.* 2, 193–9 (*June*, 1955).

The sampling distributions of the more important statistical derivates from the multivariate *t*-distribution are established. A.

ASTRONOMY . ASTROPHYSICS. GEODESY 52

522.1

8442. The Kiel radio-astronomical observatory. F. DRÖGE. *Z. Astrophys.*, **37**, *No.* 2, 125–31 (1955) In German.

A description of a radio-telescope working on 198 Mc/s: aerial area $5 \times 5\,m^2$; gain 140; beam width between half-power points $16{\cdot}8° \pm 0{\cdot}3°$ horizontal, $16{\cdot}3° \pm 0{\cdot}3°$ vertical; sensitivity 10°K in aerial temperature, $2{\cdot}05 \times 10^{-22}$W.sec in energy. The geographical co-ordinates are given. M. W. OVENDEN

523.164

8443. Chord construction for correcting aerial smoothing. R. N. BRACEWELL. *Austral. J. Phys.*, **8**, *No.* 2, 200–5 (*June*, 1955).

A graphical method is given for correcting the smoothing effect which arises when a celestial distribution of brightness temperature is scanned with an aerial beam. The method is much simpler to apply than previous methods which have been used and is no less accurate. A.

523.164 : 522.6

8444. A rotating-lobe interferometer and its application to radio astronomy. R. H. BROWN, H. P. PALMER AND A. R. THOMPSON. *Phil. Mag.*, **46**, 857–66 (*Aug.*, 1955).

An interferometer, operating on the rotating-lobe principle, is described. It is shown how the frequency of the interference patterns observed from discrete radio sources may be controlled and made independent of the baseline length and direction. The application of the instrument to observations with a short north–south baseline and a long (630λ) baseline is illustrated

by experimental results. It is pointed out that the use of this technique is of particular value for the observation of weak sources with long baselines. A.

523.164 : 551.510.535

8445. Radio star scintillations and the ionosphere. T. R. HARTZ. *Canad. J. Phys.*, **33**, *No.* 8, 476–9 (*Aug.*, 1955).

The observed intensity at the surface of the earth of radiation at a frequency of 50 Mc/sec from a radio star has been studied. A relationship is shown to exist between the fluctuations, or scintillations, in this observed radiation intensity and the angle of its incidence on the 400 km level of the earth's ionosphere. The occurrence of these scintillations is compared with other ionospheric phenomena as determined by vertical sounds from the earth. The probable cause of the fluctuations has been localized to a source in the high ionospheric regions. A.

523.164.85

8446. The influence of noise on radar meteor observations. C. D. ELLYETT AND G. J. FRASER. *Austral. J. Phys.*, **8**, *No.* 2, 273–8 (*June*, 1955).

An experimental investigation has been made of the minimum detectable echo power from meteor trails, using radar techniques at 69 Mc/s, with incoherent detection. For optimum signal-to-noise ratio the pulse width must exceed the cathode-ray tube spot width. Extraterrestrial noise is predominant at 69 Mc/s, and the receiver noise figure is found to be of only second-order importance. Variations in the effective aerial temperature introduce corresponding variations in the observed meteor rate, and must therefore be considered when meteor rates are being compared. Using artificial echoes, a minimum detectable signal-to-noise ratio of 8 db is found. The most important parameter is the total received signal energy. Both these results are in agreement with published theories. No further reduction in the size of the smallest observable meteor is likely through receiver improvement. The important features of the receiver are described. A.

523.164.85

8447. Diffusion coefficients from the rate of decay of meteor trails. A. A. WEISS. *Austral. J. Phys.*, **8**, *No.* 2, 279–88 (*June*, 1955).

The effective diffusion coefficient for a meteor trail is calculated from the theory of ambipolar diffusion and the physical constants of the upper atmosphere. The absolute value of the diffusion coefficient so calculated, and also its gradient with height, are confirmed by measurement of the rates of decay of a large number of meteor echoes of known heights. The individual values show considerable scatter, most of which is attributed to a regular diurnal variation in the value of the diffusion coefficient. Amplitude fluctuations in persistent echoes are also briefly discussed. A.

523.5 : 550.93

8448. Time interval between nucleogenesis and the formation of meteorites. G. J. WASSERBURG AND R. J. HAYDEN. Letter in *Nature* [*London*] **176**, 130–1 (*July* 16, 1955).

On the assumption that I^{129} and I^{127} were originally formed in equal amounts, the quantity of radiogenic xenon-129 in a meteorite enables this interval to be determined. An investigation of the Beardsley chondritic meteorite shows that any such increase must be less than 30%, leading to a lower limit of $0{\cdot}41 \times 10^9$ years, and this coupled with the age of the meteorite yields a figure of greater than 5×10^9 years for the time since the formation of the elements.

J. M. HOUGH

523.51

8449. Argon and helium determination in iron meteorites. W. GENTNER AND J. ZÄHRINGER. Note in *Z. Naturforsch.*, **10a**, *No.* 6, 498–9 (1955) In German.

A mass spectrographic determination of the isotopic abundances of argon and helium in four iron meteorites is given. It was found that the ratio A^{36}/He^3 was constant over a concentration range of two powers of 10, and this is briefly discussed.

J. HUGHES

523.51 : 539.155.2

8450. Isotopic composition of meteoritic hydrogen. G. EDWARDS. *Nature* [*London*] **176**, 109–11 (*July* 16, 1955).

Measurements have been made on iron meteorites and it has been found that the D/H ratio is different for the surface rust and for the interior which leads to the view that the latter is the same as for the original hydrogen incorporated during the formation of the meteorite. The ratio is 12·9% less than for average seawater. The agreement of these figures with data for carbonaceous chondrites is discussed. J. M. HOUGH

523.53

8451. Diurnal variations in the number of shower meteors detected by the forward-scattering of radio waves. I. Theory. C. O. HINES. *Canad. J. Phys.*, **33**, *No.* 9, 493–503 (*Sept.*, 1955).

Various observational factors affect the number of shower meteors which can be detected, in a given time interval, by the scattering of radio waves from the ionized meteor trails. The pertinent factors in the case of forward-scattering, where the transmitter and receiver are widely separated, are expressed approximately as functions of the position of the shower radiant. In combination, they provide an observational weight factor which may change appreciably as the radiant moves in the course of a day. The consequent diurnal variation in the occurrence of scattered signals may then be determined, and distinguished from variations due to random changes in the incidence rate of the meteors. A.

523.67

8452. Identification of the infrared spectrum of the comets. S. M. POLOSKOV. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 4, 639–42 (1955) In Russian.

It is claimed that Swings and Page [*Astrophys. J.*, **111**, 530 (1950); **108**, 526 (1948)] are wrong in identifying the infrared bands of the spectra of comets as the "red system" of CN. Their assumption presupposes an excitation mechanism other than the resonance fluorescence, hence an excitation of molecules during photo-dissociation of the "initial" molecules. In this case, however, the intensity of the "red system" would be, contrary to observation, very weak compared with the violet system. It is suggested that the

observed infrared bands are identical with those due to the $^2\Pi$–$^2\Sigma$ resonance system of N_2^+ [Meynel, *Astrophys. J.*, **113**, 583 (1951); Douglas, Abstr. 8315 (1953)]. It is also shown that the above system may be expected in the spectra of comets. F. LACHMAN

523.72

8453. On the centre–limb variation of solar radio-frequency radiation on 198 Mc/s during the eclipse of 1954 June 30. W. PRIESTER AND F. DRÖGE. *Z. Astrophys.*, **37**, *No.* 2, 132–42 (1955) In German.

The eclipse intensity curve on 198 Mc/s showed a smooth variation with slight asymmetry. The background intensity of the quiet sun was found from observations taken during the period 2 months before to 2 months after the eclipse, three radio "stars" being used as standards, and allowance for sunspots on June 30 could be made. The observations are consistent with a series of elliptical isophotes with a constant axis-ratio of $1 : (1{\cdot}24 \pm 0{\cdot}04)$. The possible range of centre–limb variation is discussed; the results are consistent with O'Brien's 1953 observations [Abstr. 8858 (1954)]. M. W. OVENDEN

523.746

8454. The latitude drift of sunspot groups. J. TUOMINEN. *Z. Astrophys.*, **37**, *No.* 3, 145–8 (1955).

Analysis of the latitude drift of long-lived sunspot groups indicates that this drift varies with a period of 22 but not of 11 years. A.

523.774

8455. Centre–limb variation of weak to moderately strong Fraunhofer lines on the solar disk. G. ELSTE. *Z. Astrophys.*, **37**, *No.* 3, 184–213 (1955) In German.

A comparison is made between observed and predicted centre–limb variations of central intensities, half-widths, and equivalent widths of a total of 10 lines of Ti (1), Ni (1), Fe (6), Fe^+ (1), and C (1) observed with a Lummer–Gehrcke interferometer attached to the Göttingen tower-telescope. The major computations for the theoretical line-profiles were carried out on an electronic computer. For a majority of the lines, agreement between observed and predicted quantities is satisfactory. The observed departures for the remaining lines may be explained by a partial dependence of the line-profile on photospheric microturbulence. D. R. BARBER

523.854.22

8456. Effect of the structural characteristics of the Galaxy on the dispersion of the random velocities of the stars and interstellar clouds. G. M. IDLIS. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 4, 635–8 (1955) In Russian.

The average mass of the most massive fluctuations of density in the Galaxy (interstellar clouds, stellar clouds and their complexes), as developed from available data, is estimated by the author at $\sim 5 \times 10^5 M_\odot$. This figure agrees with that derived under certain assumptions from Spitzer and Schwarzschild's equation $V(\tau) = V_0(1 + \tau/t_E)^{1/3}$, as well as with the results of Lebedinskii's theoretical papers (1953–4). A more detailed quantitative comparison of the above formula with the observed data is obtained using Fesenkov's and Masevich's theory of corpuscular evolution [Abstr. 6695 (1949), 5465 (1950), 42 (1952)]. The values of V (mean velocity of the objects observed in relation to the disturbing fluctuations of density) thus calculated agree well with those observed [Parenago, *Peremennye Zvezdy* (1947)] for the following star types: B3, A0, A5, F0 and the long-period Cepheids. F. LACHMAN

523.877

8457. Instability of an extensive fluid mass. N. BEL. *C.R. Acad. Sci.* [*Paris*] **241**, *No.* 2, 163–4 (*July* 11, 1955) In French.

The requisite conditions are established for the gravitational instability of a sinusoidal perturbation associated with an extensive fluid medium in non-uniform rotation, both pressure and density being maintained uniform. D. R. BARBER

523.877 : 539.172.4

Radiation flux field outside of stars and spherical reactors. *See Abstr.* 9114

PHYSICS 53

53

8458. Fermi statistics and its applications. F. SEITZ. *Rev. mod. Phys.*, **27**, *No.* 3, 249–53 (*July*, 1955). **Fermi's theory of beta-decay.** E. J. KONOPINSKI. *Ibid.* (254–7). **Fermi and neutron physics.** E. SEGRÈ. *Ibid.* (257–63). **Fermi and atomic energy.** W. H. ZINN. *Ibid.* (263–8). **Meson experiments with Enrico Fermi.** H. L. ANDERSON. *Ibid.* (269–72). **From Professor Fermi's Notebooks.** *Ibid.* (273–5).

Review papers presented at the Memorial Symposium held by the American Physical Society at Washington in April, 1955.

53

8459. Role of science in the secondary school. F. G. WATSON. *Amer. J. Phys.*, **23**, *No.* 6, 381–3 (*Sept.*, 1955).

The differences between secondary schools and colleges are clarified. In schools the population of students range widely in abilities and interests. Because most high schools are small, teachers usually are responsible for three subjects—not all necessarily being in science. Teachers are viewed as stimulators and guides who develop enthusiasm for science through their instruction. Ways for collegiate instructors to assist and encourage high school teachers are sketched. A.

53 : 62

8460. Physics in engineering—a problem in appraisal. J. D. RYDER. *Amer. J. Phys.*, **23**, *No.* 6, 331–6 (*Sept.*, 1955).

The general objectives of a course in general physics for engineers are discussed. To ascertain whether these objectives are being met, the author has reviewed several leading physics textbooks and several basic engineering textbooks in equivalent areas. He is discouraged by the multiplicity of applied topics apparently discussed in the physics courses, without

apparent major emphasis on concepts. He concludes that it might be better to ask the physics department to teach a course in atomic and nuclear physics, possibly at the junior or senior level, and allow Engineering to teach the fundamentals of the classical area as they are already doing to a large extent. See also abstract following. A.

53 : 62

8461. Physics in engineering—a rejoinder. R. N. VARNEY. *Amer. J. Phys.*, **23**, *No.* 6, 337–40 (*Sept.*, 1955).

See preceding abstract. The contentions are raised that a thoroughly integrated presentation of fundamentals is highly essential to engineering students and must be given regardless of the title or department of the professor doing it, that physics departments and texts are doing it today, not perfectly perhaps, but under considerable difficulties, and finally that physicists still have an approach and a point of view that is decidedly more basic than that of the engineer and is decidedly healthy for the engineering student to learn. A suggestion is offered for expanding the crowded four-year curriculum by bringing students from high schools a year earlier. A.

53.08 : 537

8462. Some suggestions for a laboratory practical in electrical measurements. F. T. WORRELL. *Amer. J. Phys.*, **23**, *No.* 6, 318–21 (*Sept.*, 1955).

A laboratory test is described which consists of an experimental problem. The course in electrical measurements in which this test is given emphasizes the general rather than the specific aspects of electrical measuring techniques; the test is designed to test the student's ability to meet a new experimental problem. Examples of some of the questions are given. A.

53.081

8463. On a possible extension of the notion of invariance. M. JESSEL. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 26, 2495–7 (*June* 27, 1955) In French.

Following Fleischmann [Abstr. 7098 (1954)] the electromagnetic equations are written in a form independent of the system of units employed and formal solutions invariant with respect to constitutive equations are derived. R. A. NEWING

53.081

8464. Reply by the author of "Grandeur, Mesure et Unité" to the criticism presented by M. Eskenazi. M. LANDOLT. *Istanbul Tek. Üniv. Bült.*, **7**, 79–80 (1954) In French.

See Abstr. 23 (1955). Landolt agrees that his physical quantity (grandeur) is an abstract thing and not the natural phenomenon, but maintains that his theory is less a theory of physical quantities than a justification of the calculation of the quantities and thus is not open to Eskenazi's criticism. S. WEINTROUB

53.081

8465. M. Eskenazi's reply. M. ESKENAZI. *Istanbul Tek. Üniv. Bült.*, **7**, 81–2 (1954) In French.

See Abstr. 23 (1955) and preceding abstract. Maintains that it is impossible to admit that a theory of physical quantities does not take into consideration the real characters of the quantities, but recognizes that Landolt's work is a most vigorous attempt at a solution of the problem of the relations between quantities. S. WEINTROUB

53.088

8466. Concept of the frequency of presence of a measurable quantity *G*. P. RENAUD, M. JOLY AND D. G. DERVICHIAN. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 25, 2384–7 (*June* 20, 1955) In French.

See Abstr. 7101 (1954). It is shown that there exists a domain D, in the space of the parameters which relate G and the measuring apparatus, in which the measurement does not vary. The size of D defines the frequency of presence of G. This idea is extended to a phenomenon defined by several quantities G. S. WEINTROUB

FUNDAMENTALS 530.1

530.112

8467. Some considerations regarding the principle of phase invariance. F. A. KAEMPFFER. *Canad. J. Phys.*, **33**, *No.* 8, 436–40 (*Aug.*, 1955).

Taking the view that "particles" are in fact excitations of the motion of an all-pervading medium (or "ether"), it is shown that the conservation laws characterizing the ether, which are different from the well-known laws of conservation of energy and momentum, flow from a single principle, the principle of phase invariance, provided a complex field is used to describe the ether. There are at least two different self-consistent types of Lorentz-invariant ether theories which satisfy the principle of phase invariance. A.

530.12

8468. On linear field theory. III. The gravitational equations. W. SCHERRER. *Z. Phys.*, **141**, *No.* 3, 374–85 (1955) In German.

For Pt II, see Abstr. 4335 (1955). The field equations are obtained in the form $R_{ik}-\frac{1}{2}G_{ik}R=-M_{ik}$ where in general M_{ik} involves the second derivatives of the basic functions $\psi_{i,k}$. In the special case in which only the first derivatives are involved, M_{ik} is a homogeneous quadratic form in the field variables $f_{i,kl}$ and the Einstein vacuum equations follow since $f_{i,kl}\sim 0$ for weak fields. R. A. NEWING

530.12

8469. The relativisitic group of the Einstein–Schrödinger unified theory. J. WINOGRADZKI. *J. Phys. Radium*, **16**, *No.* 6, 438–43 (*June*, 1955) In French.

It is shown that in the case of a non-symmetric connection the field equations are uniquely determined by a variation principle if the relativistic group is extended to include J-transformations [Abstr. 1494 (1955)]. These transformations reduce to Einstein's λ-transformations. R. A. NEWING

530.12

8470. The choice of the metric and of the electromagnetic field in Einstein's unified theory. Relation to the Born–Infeld theory. S. MAVRIDÈS. *J. Phys. Radium*, **16**, *No.* 6, 482–8 (*June*, 1955) In French.

See Abstr. 7106 and 8023 (1954).

530.12

8471. On a five-dimensional unified theory. I. Lagrangian. C. MORETTE-DEWITT AND B. S. DEWITT. *C.R. Acad. Sci.* [*Paris*] **241,** *No.* 2, 167–8 (*July* 11, 1955) In French.

The fundamental metric tensor and Lagrangian (in linear approximation) are set up with a view to studying the mass spectrum to which such a theory will lead. G. FIELD

530.12

8472. On a five-dimensional unified theory. II. Hamiltonian. Commutation relations. C. MORETTE-DEWITT AND B. S. DEWITT. *C.R. Acad. Sci.* [*Paris*] **241,** *No.* 3, 279–81 (*July* 18, 1955) In French.

The Hamiltonian is given, in the linear approximation, and the theory is quantized. G. FIELD

530.12

8473. On the approximate equations of the Einstein–Schrödinger theory. M.-A. TONNELAT. *C.R. Acad. Sci.* [*Paris*] **241,** *No.* 2, 168–70 (*July* 11, 1955) In French.

Field equations are obtained to the 3rd approx. and the divergence of the energy tensor is shown to vanish to this order. R. A. NEWING

530.12

8474. The use of the metric $h^{\mu\nu}$ and the fields $f^{\mu\nu}$ in obtaining the equations of motion. PHAM TAN HOANG. *C.R. Acad. Sci.* [*Paris*] **241,** *No.* 2, 170–2 (*July* 11, 1955) In French.

The symmetric and skew parts of $g^{\mu\nu}$ instead of $g_{\mu\nu}$ are taken as metric and field and a 4th order approx. to the equations of motion is derived. Callaway's result [Abstr. 3060 (1954)], that to this approx. the motion of a particle depends only on the gravitational field, is confirmed. R. A. NEWING

530.12

8475. The general solution of Einstein's equations $g^{\mu\nu}_{+-};_0 = 0$. S. MAVRIDÈS. *C.R. Acad. Sci.* [*Paris*] **241,** *No.* 2, 173–4 (*July* 11, 1955) In French.

530.12

8476. On the gravitational effects of distant rotating masses. L. BASS AND F. A. E. PIRANI. *Phil. Mag.*, **46,** 850–6 (*Aug.*, 1955).

Thirring's calculation of the gravitational field near the centre of a rotating spherical shell is corrected and elaborated. First, an additional term, representing elastic stresses, is introduced into the energy-momentum tensor; without this term the conservation laws cannot be fulfilled and the shell could not keep together during rotation. Secondly, the dependence of the gravitational effects on the mass-distribution over the shell is investigated. The quasi-centrifugal forces are to be attributed entirely to the mass-distribution on the shell arising from the mass-increase with velocity. A.

530.12 : 523.11

8477. On cosmology with variable "constant" of gravitation. K. JUST. *Z. Phys.*, **140,** *No.* 6, 648–55 (1955) In German.

The set of field equations for which $|s| \gg c^2$, $c > 0 > s$ [see Abstr. 7669 (1955)] gives an expanding world model with positive curvature, κ decreasing with time. Various difficulties arising from the model are noted. R. A. NEWING

530.12 : 530.145

8478. Remark on a previous note. E. CORINALDESI. Letter in *Nuovo Cimento* (*Ser.* 10) **2,** *No.* 1, 168 (*July*, 1955).

Results reported earlier [Abstr. 7676 (1955)] are completed by identifying two velocity independent terms in the relativistic equations of the two-body problem. R. A. NEWING

530.12 : 538.3

On the singular electromagnetic field. *See Abstr.* 8924

530.145

8479. The electromagnetic field in a Lagrangian quantum theory. K. V. ROBERTS. *Phil. Mag.*, **46,** 941–50 (*Sept.*, 1955).

The graphical rules of Feynman and Dyson are stated in a very general form, which depends only on the field Lagrangian, and does not explicitly require either the use of field operators or the construction of a Hamiltonian scheme. It is shown that by choosing these rules as a starting-point one is able to quantize the electromagnetic field in a simpler way, since there is no longer any need to modify the classical Lagrangian $\frac{1}{4}F^{\mu\nu}F_{\mu\nu}$ (which does not lead to a Hamiltonian as it stands); to impose a supplementary condition; or to employ an indefinite metric. Dyson's theorem on photon propagation functions is established, and the gauge-invariance of the S-matrix is discussed. A.

530.145 : 531.51

8480. On the quantum theory of gravitation. O. COSTA DE BEAUREGARD. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 25, 2383–4 (*June* 20, 1955) In French.

The methods of Schwinger's covariant electrodynamics are applied to Tonnelat's theory of the graviton. R. A. NEWING

530.145

8481. A survey of field theory. *Rep. Progr. Phys.*, **18,** 423–77 (1955). **I. General background.** R. E. PEIERLS (424–30). **II. Fields and particles.** A. SALAM (433–40). **III. Interactions of quantized fields.** P. T. MATTHEWS (441–50). **IV. Properties of the π-meson.** P. T. MATTHEWS (452–60). **V. High energy experiments.** G. FELDMAN (462–9). **VI. Final remarks. The new particles.** R. E. PEIERLS (470–7).

These six articles attempt to summarize the concepts and results of the field theory of elementary particles in terms which, it is hoped, will be understood by experimentalists or theoretical physicists working in other fields. Pt I is a general, partly historical, introduction. The concept of virtual states and the physical ideas underlying the renormalization of mass and charge are explained. The outline of the theory starts in Pt II, which deals with the description of a quantized field—the quantized electromagnetic field for example—and its relation to an assembly of particles. Pt III describes the interactions of such particles. It is shown how solutions to problems in electrodynamics (the interaction of electrons and positrons with photons) may be

obtained as a power series in the fine structure constant $e^2/4\pi\hbar c(=1/137)$. A number of possible meson–nucleon interactions are then developed by analogy with electrodynamics. To decide which of these actually occurs in nature, it is necessary to determine from experiment the spin and intrinsic parity of the π-meson. Pt IV is devoted to this problem. The charge independence of nuclear forces expressed in terms of isotopic spin is then used to determine, as uniquely as possible, the π-meson–nucleon interaction in qualitative agreement with experimental data. Quantitative agreement has not yet been obtained owing mainly to the largeness of the coupling constant. In Pt V the experimental evidence on π-mesons is reviewed. It is emphasized that a variety of effects can be explained on the assumption that there is a short-lived excited state of the nucleon. Pt VI starts with a discussion of the classical limit of the electromagnetic and Dirac fields and concludes with some considerations of the properties of the recently discovered heavy mesons and some general regularities of the couplings between them. 35 refs.

A.

530.145

8482. Gradient transformations of the Green's functions of charged particles. L. D. LANDAU AND I. M. KHALATNIKOV. *Zh. éksper. teor. Fiz.*, **29**, *No.* 1(7), 89–93 (1955) In Russian.

Changes in the particle and photon Green's functions and in the vertex part from $A_\mu \rightarrow A_\mu + \partial\phi/\partial x_\mu$ are considered. G. E. BROWN

530.145

8483. An algebraic viewpoint in the macroscopic theory of observation. R. VALLÉE. *C.R. Acad. Sci.* [*Paris*] **241**, *No.* 2, 179–80 (*July* 11, 1955) In French.

Some further remarks about two operators, A and Z, which were previously introduced [Abstr. 1440 (1952)] into the theory. An interpretation is now given of the sum and the product of two such operators. L. S. GODDARD

530.145

8484. Field equations from particle equations. W. J. ARCHIBALD. *Canad. J. Phys.*, **33**, *No.* 9, 565–72 (*Sept.*, 1955).

A simple point of view is developed which shows how various types of field equations may be obtained from the relativistic Hamiltonian of a particle. A.

530.145

8485. Quantum theory of fields. I. E. S. FRADKIN. *Zh. éksper. teor. Fiz.*, **29**, *No.* 1(7), 121–34 (1955) In Russian.

The variational equations of Schwinger are derived from the usual field theory rather than from a variational principle. Renormalization has been carried out without expansion in the coupling constant as outlined previously [Abstr. 44 (1955)]; no attempt is made to solve the equations so obtained.

G. E. BROWN

530.145

8486. Causality conditions and dispersion relations. I. Boson fields. M. L. GOLDBERGER. *Phys. Rev.*, **99**, *No.* 3, 979–85 (*Aug.* 1, 1955).

The dispersion relations of Kramers and Kronig as generalized for charged and neutral Bose particles with finite rest mass are derived in a new way using the formalism of quantum field theory. The alternative forms of dispersion relations obtained by making various assumptions on the high-frequency limit of total cross-sections are used to obtain information about the high-frequency behaviour of the total cross-section for the scattering of γ-rays by electrons. A.

530.145

8487. Quantum field theory. T. H. R. SKYRME. *Proc. Roy. Soc. A*, **231**, 321–35 (*Sept.* 6, 1955).

A functional expression resembling the scattering matrix is introduced into classical field theory, and with this foundation a postulate of quantization is introduced analogous to the definitions of Feynmann. From this are derived some alternative and more familiar forms of field theory. A variational principle is introduced which provides a relativistic analogue of the familiar non-relativistic variational principle for the Schrödinger equation. A.

530.145

8488. Time reversal in field theory. J. S. BELL. *Proc. Roy. Soc. A.*, **231**, 479–95 (*Sept.* 20, 1955).

The idea of reversibility in time as applied to quantized fields is expounded from first principles. It is shown that in the usual theories reversibility of a certain kind is a concomitant of relativistic invariance and symmetry in space. Finally the relations between transition amplitudes consequent on the reversibility are derived. A.

530.145

8489. The solution of the system of equations for the vacuum functional. N. P. KLEPIKOV. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 6, 1057–9 (1955) In Russian.

Variational differential equations of Schwinger's type for the vacuum functional in quantum electrodynamics are solved formally by the techniques of functional integration. J. M. RADCLIFFE

530.145

8490. On a new derivation of the equations for the Green's functions in quantum electrodynamics. M. K. POLIVANOV. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 6, 1061–3 (1955) In Russian.

Schwinger's equations are obtained by a method which employs a modification of Wick's ordering techniques. J. M. RADCLIFFE

530.145 : 538.3

8491. The representation of the electromagnetic field by retarded potentials. I. S. ARZHANYKH. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 6, 1053–6 (1955) In Russian.

Extends earlier work [Abstr. 6456 (1953)] to the dynamical case. J. M. RADCLIFFE

530.145

8492. Non-linear interactions and nuclear saturation. E. CLEMENTEL AND C. VILLI. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 6, 1273–6 (*June*, 1955).

Approximate solutions of the non-linear equation $-\Delta\phi(r) + \mu^2\phi(r)[1 - \lambda\phi(r)]^{-1} = gp(r)$ for the meson field $\phi(r)$ suggest the correct saturation for heavy nuclei if $g^2 = 5{\cdot}1$. The form of the nuclear potential well can be written down explicitly: it is bell-shaped

with a central depth of −38·2 MeV. The mesons in a nucleus would exhibit an effective mass of ∼636 m_e.
W. J. SWIATECKI

530.145

8493. Low-energy theorems for renormalizable field theories. A. KLEIN. *Phys. Rev.*, **99**, *No.* 3, 998–1008 (*Aug.* 1, 1955).

A general method is described whereby the low-energy behaviour of collision processes can be investigated systematically. The basic procedure is the construction of the renormalized Green's functions for the participating particles in the presence of external sources. For processes involving the collision of a boson with a fermion—photon scattering, meson scattering, and photoproduction of mesons—one requires the propagation function of a nucleon in the presence of external electromagnetic and meson fields, as well as the propagator for a meson in an electromagnetic field. The rather direct relation of these functions to the various transition matrices is derived. The possible forms of the Green's functions are limited by the principles of Lorentz, gauge and charge conjugation invariance. Their detailed structure is determined in part by the requirement that they describe particles of known mass, charge, magnetic moment, and mesic coupling constant. These conditions are sufficient to imply a number of theorems. For example, it is shown that the amplitude for photon–proton scattering is given correctly up to terms of first order in the photon energy by a Born approximation calculation, if one assigns to the proton its experimental charge and magnetic moment. If one includes the meson–nucleon coupling constant in this set of parameters, then perturbation theory is also valid for the leading terms in a momentum-energy expansion of the *P*-wave in meson–nucleon scattering, the *S*- and *P*-waves associated with the nucleon current in photomeson production, and the entire meson current for the same process. The methods employed to establish the theorems are extended in order to provide a phenomenological framework for the description of the experiments for energies low enough so that the expansions in boson energy are still valid, but for which the deviations from the theorems are of practical significance. Thus, it is suggested that for the description of photon scattering one should attribute an electric and a magnetic polarizability to the nucleon. The description of the *P*-wave in meson–nucleon scattering also requires the introduction of two additional parameters. From the manner in which these enter the scattering amplitude, it can be concluded that the phase shift in the state of angular momentum and isotopic spin 3/2 is enhanced compared to its Born value, if only the phase shifts in the other states deviate in the opposite direction. Finally, parameters are introduced to describe the *S*-wave in meson-scattering, and the basis for a phenomenological description of photoproduction is indicated. A.

530.145

8494. Radiative correction to high-energy electron scattering. H. SUURA. *Phys. Rev.*, **99**, *No.* 3, 1020–8 (*Aug.* 1, 1955).

The one-photon radiative correction to the high-energy electron scattering by a nuclear field is analysed to all orders of Born approximation for the nuclear potential. The leading term of the fractional decrease of the elastic scattering cross-section is shown to be exactly the same as that given by the first Born approximation. A detailed analysis of the effect of the long Coulomb tail on the infrared divergence is made. Also, an analysis is made on the origin of the log$m$ term which appears in the radiative correction.
A.

530.145

8495. Quantum effects in the interaction between free electrons and electromagnetic fields. P. S. FARAGÓ AND G. MARX. *Phys. Rev.*, **99**, *No.* 4, 1063–4 (*Aug.* 15, 1955).

An electron beam shot through a transverse r.f. field may suffer a directional spread. If experimental conditions are suitably chosen, the directional spread may be due only to the quantum dispersion of energy exchange between free electrons and r.f. field. A simple collector electrode system might allow not only the detection of the directional spread of the electrons, but the presence of a quantum effect might be checked by plotting the collector current *v.* r.f. field amplitude, the plot for the quantum effect being different from those for classical effects. The results of various theoretical treatments of the effect are briefly compared, both from the point of view of their principal foundations and of the possibility of their experimental verification. A.

530.145

8496. Theory of nucleons. D. I. BLOKHINTSEV. *Zh. éksper. teor. Fiz.*, **29**, *No.* 1(7) 33–6 (1955) In Russian.

The π-mesons in this theory interact only indirectly with nucleons, through an intermediary *K*-meson field. This gives rise to a form-factor in the interaction between π-meson and nucleon, providing a non-local interaction. G. E. BROWN

530.145

8497. On the theory of elementary particles. G. HEBER. *Ann. Phys.* [*Leipzig*] **16**, *No.* 1–2, 43–51 (1955) In German.

The condition that the sum of the "inner kinetic energy" of the bare source and the interaction energy with the field be a mimimum is used to calculate the radius of a finite non-relativistic scalar source model in interaction with a real scalar field. A sufficiently large, plausible interaction constant gives a radius of the order 10^{-13} cm. W. A. HEPNER

530.145

8498. On the practical solution of the relativistic one-electron equation. E. A. HYLLERAAS. *Z. Phys.*, **140**, *No.* 6, 626–31 (1955) In German.

The large and small components of the wave-function of the Dirac equation for the Kepler problem are separated and expressed explicitly in terms of Laguerre functions by solution of appropriate 2nd-order differential equations. R. A. NEWING

530.145

8499. Possible mathematical formulation of the Gell-Mann model for new particles. B. D'ESPAGNAT AND J. PRENTKI. Letter in *Phys. Rev.*, **99**, *No.* 1, 328–9 (*July* 1, 1955).

Gell-Mann's assignations of isotopic spin and

"strangeness" are put on an axiomatic basis by assuming that all strong interactions are invariant under both rotations and reflections in a three-dimensional isotopic spin space. P. T. MATTHEWS

530.145

8500. Scattering of fast neutrons by non-spherical nuclei. I. S. I. DROZDOV. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 6, 734–6 (1955) In Russian.

General scattering formulae are derived for the adiabatic case, in which the nucleus rotates slowly and can be considered stationary during the process. The scattering amplitude is evaluated in the semi-classical approximation for an ellipsoidal black body scatterer. G. E. BROWN

530.145

8501. Scattering of fast neutrons by non-spherical nuclei. II. S. I. DROZDOV. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 6, 736–8 (1955) In Russian.

Cross-sections for elastic and inelastic (with excitation of nuclear rotation states) scattering are obtained for high-energy neutrons of $kR = 10$ for the cases where the nucleus is spherical and non-spherical in the ground state. G. E. BROWN

530.145

8502. Method of truncated field equations and its application to the scattering of mesons by nucleons. V. P. SILIN, I. E. TAMM AND V. YA. FAĬNBERG. *Zh. éksper. teor. Fiz.*, **29**, *No.* 1(7), 6–19 (1955) In Russian.

The so-called Tamm–Dancoff method is reformulated, beginning from covariant equations. From these, equations in three-dimensional momentum space are obtained. Boundary conditions are considered. Dyson's formulation in the physical vacuum [Abstr. 5854 (1953) 66, 97 (1954)] is applied and the relation to the old formulation in the bare vacuum discussed. The system of meson + nucleon is considered, taking into account coupling with amplitudes describing three or fewer virtual particles. Results obtained numerically by restriction to *S*- and *P*-waves are not included here, but will be reported separately. Renormalization is briefly considered. G. F. BROWN

530.145

8503. Scattering of nucleons by nucleons in the theory of damping. G. F. ZHARKOV. *Zh. éksper. teor. Fiz.*, **29**, *No.* 1(7), 85–8 (1955) In Russian.

The total elastic cross-section is calculated, but the experimental p–p cross-section, which is approximately energy-independent, cannot be reproduced. G. E. BROWN

530.145

8504. Exchange scattering of the 380 MeV neutrons by deuterons and the spin dependence of exchange forces. V. P. DZHELEPOV, YU. M. KAZARINOV AND V. B. FLYAGIN. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 4, 655–8 (1955) In Russian.

Pomeranchuk [Abstr. 4921 (1952)] pointed out that, owing to the parallellism of the spins of constituent particles of the deuteron, the probability of the exchange (n–d) scattering, accompanied by the spin exchange between the nucleons, decreases sharply in certain conditions. This enables some conclusions to be drawn on the spin dependence of the exchange forces. The authors' experiments were conducted for scattering angles near 0°, since in this case the cross-section of the exchange (n–p) scattering does not depend on the angle value, while central forces only are active between the nucleons. A telescope consisting of 3 scintillation (collision) counters measured the difference between the scattering protons emerging at a given angle with regard to the neutron beam from the scattering appliances with heavy, and ordinary, water, containing equal numbers of the H and D nuclei, respectively. The average energy of the neutrons used was 380 MeV. The measured difference is proportional to the difference of cross-sections of the exchange collisions (n–p) and (n–d). It was found, in agreement with Pomeranchuk's theory, that the yield of protons in the exchange (n–d) collisions at angles $\rightarrow 0°$ was much smaller than for the (n–p) collisions; it also was somewhat (10–15%) smaller at angles 15–40°. The determined ratio $(0{\cdot}2 \pm 0{\cdot}035)$ of cross-sections for the angle 0° allows to estimate roughly that the variation of amplitudes of the spin/non-exchange and spin/exchange scattering is confined between 0·5 and 1·2. F. LACHMAN

530.145

8505. Completeness of stationary scattering states. II. N. G. VAN KAMPEN. *Physica*, **21**, *No.* 7, 579–88 (*July*, 1955).

The question is to what extent the usual concepts apply to the general form of the *S*-matrix envisaged in Pt I [Abstr. 3445 (1955)], viz. an S that is not holomorphic in the upper half plane, but for which the stationary scattering states are still a complete set. The answer is that it is again possible to find the explicit expansion of an arbitrary function with respect to this set, so that the evolution of an arbitrary initial state can be calculated. Emission can be described by choosing a superposition of stationary states in such a way that the wave-function vanishes initially. Resonance levels and excited states, however, can only be uniquely defined if an analytic continuation of S is possible. A.

530.145

8506. Feynman amplitudes and strong-coupling pion theory. H. MIYAZAWA. *Phys. Rev.*, **99**, *No.* 3, 944–56 (*Aug.* 1, 1955).

By a method proposed by Gell-Mann and Goldberger for the treatment of the pion–nucleon problem, the case of strong pseudoscalar coupling is studied. Contributions from the closed loops in Feynman diagrams are neglected, though virtual nucleon pair creations are otherwise taken into account. The nucleon recoil turns out to be a small perturbation in the strong-coupling approximation. The theory is not covariant and no attempt is made to renormalize the divergent quantities. Divergent integrals are cut off arbitrarily. The main *P*-wave interaction is spin-independent although the next order term is the usual spin-dependent interaction. Magnetic moments of the nucleons are not in agreement with experiments. Nucleons have isobaric states with negative excitation energies. The implication of these states is discussed. The isobaric state plays a rôle as an intermediate state in pion–nucleon scattering and explains the inequality of the two *S*-phase shifts. A.

530.145

8507. Pion–nucleon scattering at high energies. A. N. Mitra. *Phys. Rev.*, **99**, *No.* 3, 957–65 (*Aug.* 1, 1955).

The pseudoscalar theory in the Tamm–Dancoff approximation is applied to high-energy pion–nucleon scattering with a view to explaining the observed maximum in π^--p scattering around 1 BeV as a resonant interaction. The integral equation is solved for the $D_{\frac{3}{2}}$-state of $T = \frac{1}{2}$ which is attractive. The various singularities in the kernel and the wave-function are taken into account in a semianalytical fashion. A short derivation is given of the complex integral equation which takes the effects of meson production into account, and it is solved in an approximate manner. It is found that, contrary to the original expectation of a resonant interaction, the increase of $D_{\frac{3}{2},\frac{1}{2}}$ phase shift over the Born approximation is not large. Also the effects of meson production are not found to be very significant over the energy range 1 BeV to 2 BeV. This last is contrary to the observations in this energy range. A.

530.145

8508. Neutron–electron interaction. G. Salzman. *Phys. Rev.*, **99**, *No.* 3, 973–9 (*Aug.* 1, 1955).

The effective neutron–electron interaction is calculated with the cut-off pseudoscalar meson theory and neglect of nucleon recoil. Values of $-7{\cdot}1$ and $-8{\cdot}6$ keV are obtained for the meson contribution with two different shapes for the cut-off function. The nucleon contribution is ambiguous in the cut-off theory since the shape of the core charge is undetermined. It is shown that if the no-recoil theory with cut-off is interpreted to be the limit, as the nucleon mass becomes infinite, of a relativistic theory with a cut-off, then the contribution of the anomalous magnetic moment (or Foldy) term is not contained in the calculation. Since the Foldy term alone accounts for the major part of the experimental interaction, the sum of pion and nucleon charge contributions in this theory, if correct, should be at most of the order of a few hundred eV, or an order of magnitude less than the pion part. Finally, a brief calculation is made to illustrate the fact that, if spread out in a plausible way, the nucleon core charge could effect the needed cancellation. A.

530.145

8509. Application of dispersion relations to pion–nucleon scattering. M. L. Goldberger, H. Miyazawa and R. Oehme. *Phys. Rev.*, **99**, *No.* 3, 986–8 (*Aug.* 1, 1955).

The generalized Kramers–Kronig dispersion relations for charged bosons are used to treat the problem of pion–nucleon scattering. The complications associated with the charge of the pions are discussed. The importance of a "bound state" corresponding to the neutron is emphasized and its contribution to the scattering amplitude is computed rigorously, assuming only that pions are pseudoscalar and that the interaction with nucleons is charge-independent. The connection between the exact dispersion relations derived here and the approximate equations for pion–nucleon scattering given by Low is discussed. A rigorous effective-range relation is derived. A.

530.145

8510. Quasi-bound states of the pion–nucleon system in the lowest Tamm–Dancoff approximation. B. P. Nigam and H. P. Noyes. *Phys. Rev.*, **99**, *No.* 3, 989–95 (*Aug.* 1, 1955).

The question is asked whether the lowest-order Tamm–Dancoff equation, which agrees with the observed p-state meson–nucleon scattering for $G^2/4\pi \sim 15$, leads to a quasi-bound state of high angular momentum capable of being identified with the Λ^0-particle. Both a static potential approximation and an approximate form of the integral equation indicate that values of $G^2/4\pi$ of the order of several hundred would be required to give sufficient binding. Although the results are not quantitatively reliable, the authors feel they indicate that either the T-D approximation is inadequate for this problem or that the Λ^0-particle cannot be a quasi-bound state of the pion–nucleon system. A.

530.145

8511. Phase shift formulas for nucleon–nucleon scattering. S. C. Wright. *Phys. Rev.*, **99**, *No.* 3, 996–8 (*Aug.* 1, 1955).

An explicit formula for the scattering spin matrix in terms of phase shifts and mixing parameters is derived for the case of nucleon–nucleon scattering. The treatment is non-relativistic and assumes that charge independence is valid. A.

530.145

8512. The collisions of nucleons with deuterons. A. H. de Borde and H. S. W. Massey. *Proc. Phys. Soc. A*, **68**, *Pt* 9, 769–80 (*Sept.*, 1955).

A considerable amount of theoretical data (assuming central nuclear forces) is now available concerning the elastic scattering of nucleons with energies up to 16 MeV by deuterons. Buckingham, Hubbard and Massey have taken the force to be of exponential shape with range consistent with the binding energy of the deuteron and triton while Christian and Gammel have used Yukawa and Gaussian shape interactions with ranges consistent with all relevant two-body data but which are considerably too short to give the correct binding energy of the triton on the assumption of purely central forces. In the present paper the former calculations have been extended to allow fully for the contributions from high order phases. The dependence of the theoretical predictions on the assumptions made about the range, shape and exchange character of the nuclear forces is discussed in detail. It is shown that the observed data are inconsistent with the assumption of mainly ordinary forces even for the least sensitive case of the short range Gaussian interaction. Extension of the theory to include explicitly the tensor force is likely to be worth while as providing useful information about nuclear forces. A.

530.145

8513. Variational calculation of electron scattering by a static potential. L. Mower. *Phys. Rev.*, **99**, *No.* 4, 1065–9 (*Aug.* 15, 1955).

The Schwinger variational method, for the approximate determination of scattering amplitude, is tested for accuracy in the case of the elastic scattering of electrons from the static potential $V(\mathbf{r}) = -e^2V_0e^{-\lambda r}/r$,

by using eight different forms of trial wave-functions. The results are compared by checking the closeness of fit of the associated scattering amplitude with an exact solution to the problem. In the course of the calculation a number of expressions, of use in more complicated problems, were obtained and are recorded. The parameter values used in the test were $a_0\lambda = 8/3$, $k^2 = (0{\cdot}72\lambda)^2$, $V_0 = 7{\cdot}8$, where a_0 is the first Bohr orbit radius for hydrogen. A.

530.145

8514. On the connection between the *S*-matrix and normalization integrals in quantum mechanics. G. LÜDERS. *Z. Naturforsch.*, **10a**, *No.* 7, 581–4 (1955) In German.

An investigation of the zero angular momentum solutions of the non-relativistic Schrödinger equation with a spherically symmetrical potential of finite range yields the following results: (1) The well-known connection between the residue of the *S*-matrix at the poles corresponding to bound states and the normalization integral. (2) A relation of the rate of change of the *S*-matrix with the (real) wave-number and the normalization integral inside the range. This leads to Wigner's inequality [Abstr. 4376 (1955)].

W. A. HEPNER

530.145

8515. On Lorentz transformations and continuity equations of angular momentum in relativistic quantum mechanics. T. SHIBATA. *J. Sci. Hiroshima Univ. A*, **18**, *No.* 3, 391–8 (*March*, 1955).

The infinitesimal transformations of the 3-parameter group previously considered [Abstr. 6256–8 (1954)] are shown to be $\delta x_\mu = (k_\mu\delta\omega_\nu - k_\nu\delta\omega_\mu)x_\nu$, where k_μ is the 4-vector $[\boldsymbol{d}; i]$. The angular momentum tensor then satisfies the equations $k_\mu \frac{\partial}{\partial x_\sigma} M_{\mu\nu\sigma} = 0$ and for axial symmetry $k_\mu \varepsilon_{\mu\nu\kappa\lambda} \frac{\partial}{\partial x_\sigma} M_{\kappa\lambda\sigma} = 0$.

R. A. NEWING

530.145

8516. Reduction of relativistic two-particle wave equations to approximate forms. III. W. A. BARKER AND F. N. GLOVER. *Phys. Rev.*, **99**, *No.* 1, 317–24 (*July* 1, 1955).

For Pt II, see Abstr. 1074 (1954). The interaction between two fermions of charge ϵ_I and ϵ_{II} and intrinsic magnetic moment μ_I and μ_{II} is described by a sixteen-component wave equation of the Breit type. The method of reduction of two-particle wave equations, as given in Pt I and II is used to convert this equation to an approximate four-component Pauli equation. A simple perturbation calculation is used to determine the contribution of the intrinsic magnetic moments to the fine and hyperfine structure of hydrogen and positronium. A.

530.151

8517. A theory of action-at-a-distance. G. B. BROWN. *Proc. Phys. Soc. B*, **68**, *Pt* 9, 672–8 (*Sept.*, 1955).

A theory of non-instantaneous action-at-a-distance and physical relativity is used to develop a force-formula for particles in relative motion. The velocity terms are derived from the forces between electrical circuits, and the acceleration terms from experiments with oscillators. The formula so obtained, when corrected for "retardation" accounts for electromagnetic induction. On the hypothesis that the variation of force with motion is the same for gravitational forces, an explanation of inertia is given in terms of the total amount of matter in the universe and its distribution, in quantitative agreement with present estimates of the mean density. A "red-shift" near large bodies and a perihelion motion of the planets also follows. This unified theory of gravitational and electrical force appears capable of giving a physical explanation of the macroscopic phenomena of physics. A.

530.162

8518. The statistical description of assemblies with collective interaction. III. Alternative formulations of the charge kinetics. G. ECKER. *Z. Phys.*, **141**, *No.* 3, 294–306 (1955) In German.

Discusses the various formulations applicable when the conditions for the validity of the collective description, discussed in two previous papers [Abstr. 5899, 5900 (1955)], are fulfilled. The limited range of applicability of each approach, consequent on the approximations involved, are discussed, and it is shown that this can account for certain discrepancies in the results obtained by a number of different authors.

E. A. ASH

530.162

8519. On the article "On the spectrum of excited systems of many particles." V. P. SILIN. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 6, 749–50 (1955) In Russian.

The former treatment [Abstr. 755 (1955)] is generalized by taking into account correlations arising from particle identity for particles in different spin states. This gives rise to spin density vibrations, equations for which are given. G. E. BROWN

530.162

8520. Behavior of a Bose system. G. V. CHESTER. *Phys. Rev.*, **99**, *No.* 4, 1062–3 (*Aug.* 15, 1955).

It is shown that a weakly interacting system of Bose particles undergoes a second-order transition both under conditions of constant volume and under conditions of constant pressure. This type of behaviour is qualitatively identical with that exhibited by liquid helium. A.

530.162

8521. On the use of grand ensembles in statistical mechanics; a new derivation of Saha's formula. D. TER HAAR. *Amer. J. Phys.*, **23**, *No.* 6, 326–31 (*Sept.*, 1955).

The advantages of using the method of the grand ensembles are discussed. As a special case Saha's formula for dissociation equilibria is derived using the method of the quantum-mechanical canonical grand ensembles. One of the advantages in this case is that it is possible at each step to take stock of the simplifying assumptions made during the derivation. A.

530.162 : 536.7

8522. Stability of the homogeneous phase. II. Determination of the limit of stability. I. Z. FISHER. *Zh. éksper. teor. Fiz.*, **28**, *No.* 4, 437–46 (1955) In Russian.

A criterion for the stability of a homogeneous phase

is developed from the general theory of Pt I [Abstr. 5901 (1955)]. Fundamental properties of systems in the neighbourhood of the limiting points of stability are analysed. Two examples of the application of this criterion (for two systems having the limiting points of different types) are discussed. F. LACHMAN

530.162 : 536.7

8523. Stability of the homogeneous phase. III. Theory of the crystallization curve. I. Z. FISHER. *Zh. éksper. teor. Fiz.*, **28**, *No.* 4, 447–51 (1955) In Russian.

The empirical rule of Simon [Simon, Ruhemann and Edwards, *Z. phys. Chem. B* **6**, 331 (1930)] $p_{fus}(T) = -A + BT^m$ for determining the pressure along the line of fusion of simple substances is developed from the theory of the limit of stability (see preceding abstract). The comparison between experiment and theory shows that the model accepted can be used in the first approximation to describe the properties of the fusion curve of real liquids. F. LACHMAN

530.162 : 537.533.75 : 537.534.75

8524. Straggling of the range of fast particles as a stochastic process. A. RAMAKRISHNAN AND P. M. MATHEWS. *Proc. Indian Acad. Sci. A*, **41**, *No.* 5, 202–9 (*May*, 1955).

The equation on the probability function can be solved if simplifying assumptions are made about the dependence of ionization and radiation losses on energy. This model is compared with an alternative model which has been proposed by Janossy.

G. E. BROWN

GENERAL MECHANICS MECHANICS OF SOLIDS 531

531.259.1 : 539.319

8525. Stress-functions of three-dimensional anisotropic elasticity. E. KRÖNER. *Z. Phys.*, **141**, *No.* 3, 386–98 (1955) In German.

The method of dealing with internal stresses by means of stress functions which are easily related to the "incompatibility tensor" which was developed in an earlier paper [Abstr. 1561 (1955)], is extended to anisotropic elasticity. The case of cubic symmetry is dealt with explicitly, and it is shown how the method may be applied to dislocations in cubic media.

W. M. LOMER

MECHANICAL MEASUREMENTS 531.7

531.711 : 535

8526. Light waves and length standards. I. C. GARDNER. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 685–90 (*Sept.*, 1955).

A brief history of earlier standards of length and of the standards now in use is given. The plan to substitute a wavelength of light for the present international platinum–iridium prototype metre as a standard of length is now under consideration by the appropriate international committees. The advantages of the proposed plan, the different isotope sources of monochromatic radiation that have been suggested by different countries, and the present status of the proposed change are presented. A.

531 767 : 621.317.79.029.6 : 538.566

A simplified form of microwave interferometer for speed measurements. *See Abstr.* 8931

531.787

8527. Adjustment at a distance of small displacements in a medium subjected to high hydrostatic pressure. B. GALPERIN, J. SAUREL, A. LECOCQ AND B. VODAR. Letter in *J. Phys. Radium*, **16**, *No.* 6, 492–3 (*June*, 1955) In French.

An electrical arrangement for the control and detection of the top of a Hg column in a non-metallic capillary enclosing a volume of gas at high pressure. The Hg is connected to an oscillator producing 3 V at 455 kc/s and an electrode, consisting of a metallic film deposited on the outside of the capillary above the column, to an amplifier and receiver. Tested at atmospheric pressure, the precision is of the order of 0·2 mm in a 0·5 mm dia. capillary. A curve of receiver current against position is given. S. WEINTROUB

531.787 : 541.127

8528. A sensitive manometer for rapid chemical reactions. E. K. RIDEAL AND A. J. B. ROBERTSON. *J. sci. Instrum.*, **32**, *No.* 9, 349–50 (*Sept.*, 1955).

A manometer is described for the pressure range 1 to 10^{-4} mm of mercury with a response time of 10^{-4} sec. The pressure change deflects a thin stainless steel diaphragm which forms the moving plate of an electrical condenser. The capacity changes are converted to voltage changes and recorded on a cathode-ray tube. A.

531.787.3

8529. A new method for the absolute measurement of high pressures. R. S. DADSON. *Nature* [*London*] **176**, 188–9 (*July* 30, 1955).

A preliminary description of a method developed at the National Physical Laboratory for the calibration of pressure balances. Using the principle of similarity as applied to balances of the same dimensions but of different materials it is shown that for two piston-cylinder assemblies consisting of materials whose elastic constants differ in a known ratio, the distortions, under applied pressure, of the two assemblies remain proportional in certain circumstances throughout the range of pressure. The N.P.L. experiments cover the range up to 3 000 atm and the two materials used are hard tool steel and a special type of bronze of high tensile strength. The elastic moduli ratio is 1·44 : 1. The variation in effective area with pressure can be measured to within a few parts in 10^5 of the whole area. To obtain the absolute value of pressure the effective area is determined at a low pressure where distortion is negligible, either by comparison with a Hg manometer or by computation from the measured dimensions of the piston and cylinder. S. WEINTROUB

531.787.6 : 533.6.011.311

8530. Micromanometer for measuring boundary layer profiles. A. M. O. SMITH AND J. S. MURPHY. *Rev. sci. Instrum.*, **26**, *No.* 8, 777–81 (*Aug.*, 1955).

A micromanometer is described which satisfies the

requirements for measuring laminar or turbulent boundary layer profiles in incompressible flow. It is a design based on the U-tube principle and has a demonstrated accuracy of $\pm 0{\cdot}0002$ in. H_2O for pressure differentials less than $0{\cdot}8$ in. H_2O and $\pm 0{\cdot}001$ in. H_2O for measurements in the range $0{\cdot}8$ to 24 in. H_2O. The lag time of the instrument is small, resulting in economical use of testing time. Results of experiments to find an optimum manometer fluid and the manometer accuracy are included. Measurements of temperature effects show good correlation with theory. Typical boundary layer profiles measured with the micromanometer exhibit a high degree of consistency and lack of scatter. A.

MECHANICS OF FLUIDS 532

532.13 : 539.89

8531. High pressure investigations. III. The viscosity of compressed liquids. E. Kuss. *Z. angew. Phys.*, **7**, *No.* 8, 372–8 (1955) In German.

For Pt II, see Abstr. 9106 (1952). A falling-sphere viscometer for measurements in the region of $0{\cdot}005$ poise at pressures up to 2000 atm. is described. The sphere is controlled, and its descent detected electromagnetically. Measurements on a large, number of liquids prove that a rough but definite relation exists between the pressure coefficient of viscosity and the slope of the m.p.–pressure curve. Further studies and more accurate approximations are to be published. T. C. TOYE

532.13

8532. Non-Newtonian viscosity of solutions of ellipsoidal particles. H. A. Scheraga. *J. chem. Phys.*, **23**, *No.* 8, 1526–32 (*Aug.*, 1955).

The specific viscosity and its dependence on velocity gradient play an important rôle in studies of the structure of macromolecules in dilute solution. A satisfactory theoretical interpretation of the non-Newtonian viscosity of solutions of ellipsoidal particles has been given by Kuhn and Kuhn, and also, by Saito, who made use of Peterlin's distribution function for the orientation of particle axes in the streaming liquid and calculated the energy dissipation due to both the hydrodynamic orientation and the Brownian motion. Also, a theory for the non-Newtonian viscosity of solutions of rod-like particles has been developed by Kirkwood. These theories involve extensive computations which have been carried out here with the aid of a computing machine by expressing Saito's results in terms of Legendre coefficients previously evaluated in the related problem of double refraction of flow. As a result, data are available for the dependence of the viscosity factor ν on axial ratio and on the parameter α, where $\alpha = G/\Theta$, G being the velocity gradient in $\sec^{-1}$ and Θ being the rotary diffusion constant in $\sec^{-1}$. With these data it will be possible to determine the rotary diffusion constants of ellipsoidal particles from the non-Newtonian viscosity of their solutions, and also to correct viscosity measurements to zero velocity gradient in order to obtain the intrinsic viscosity. Data are also included for the evaluation of Θ from the dependence of ν at $\alpha = 0$ on the frequency of periodic shear waves. A.

532.137

8533. Measurement of the viscosity of glass. M. Ondráček. *Slaboproudý Obzor*, **16**, *No.* 7, 370–7 (1955) In Czech.

An elementary exposition of the methods of measuring viscosity is followed by the description of two apparatuses for measuring the viscosity of glass, one for highly viscous, and the other for less viscous glasses. The methods are suitable for routine measurements at temperatures up to 1200°C. A brief analysis of the errors involved is given. P. CUCKA

532.3

8534. The siphon balance. L. E. Dodd. *Amer. J. Phys.*, **23**, *No.* 6, 313–17 (*Sept.*, 1955).

A balance of special design demonstrates the principle of the siphon, and incidentally, if desired, that of Archimedes at the same time. A vertical rod, ending at the top in a hook that hangs from a knife-edge, supports a horizontal platform at its centre. Placed symmetrically on the platform near its ends are two equal beakers containing water in equal amounts. If the beakers are connected by a siphon tube, when water is added to or taken from either of them, the system will rebalance itself automatically. After rebalance, the volumes of water in the beakers are again equal. Putting a floating object into either beaker causes the same deflection that the same weight of water would (Archimedes' principle), and again the pointer returns automatically to zero. If the floating object is now removed, the balance behaves as if the same weight of water had been removed. But laying a weight on the platform outside a beaker causes the siphon to increase the deflection to a new equilibrium value. A.

532.51

8535. "Rotons" in quantum hydrodynamics. G. R. Allcock and C. G. Kuper. *Proc. Roy. Soc. A*, **231**, 226–43 (*Aug.* 22, 1955).

The quantum-mechanical Hamiltonian obtained by Ziman and by Thellung [Abstr. 6721, 6726 (1953)] for an ideal liquid is diagonalized in the approximation of small compressibility. On taking account of the interaction terms between "phonon" and "roton" variables, the roton rest energy is found to be proportional to the inverse of the sound velocity and to the ninth power of the wave-number cut-off. A.

532.57 : 621.317.79

8536. A recording water velocity meter. M. J. Wilkie. *J. sci. Instrum.*, **32**, *No.* 9, 350–3 (*Sept.*, 1955).

An account is given of an instrument suitable for measuring and recording water velocities from 1–2 cm/sec to several m/sec using a miniature propeller-type current meter. Each propeller blade in passing a fixed electrode slightly increases the impedance between this electrode and the supporting frame of the propeller, generating a voltage pulse in the associated circuit. The pulse-rate is measured by an electronic tachometer. The range and accuracy are discussed and polar diagrams presented, showing the effect of different propeller mountings. A.

532.582.7

8537. The sedimentation of suspensions of spheres. R. L. WHITMORE. *Brit. J. appl. Phys.*, **6**, *No.* 7, 239–45 (*July*, 1955).

An experimental investigation of Hawksley's equation [*Conference on some aspects of fluid flow*, p. 114 (1950)] for the sedimentation of suspensions of spheres has shown close agreement with the theory, except that the derived value of Einstein's viscosity constant appears to vary with the size range, possibly exceeding 3·4 for equi-sized spheres. When spheres of the same density as the sedimentary fluid were added to the suspension, a slight decrease in settling rate was produced at total volume concentrations not exceeding about 10%. Above this figure, appreciable increases in settling rate were found and were attributed to hydrodynamic attractive-forces between the spheres leading to the development of vertical streams in the suspension. A.

532.595

8538. Propagation of non-periodic pressure waves in a tube with elastic walls. E. SCHAFFHAUSER AND V. HARDUNG. *Helv. phys. Acta*, **28**, *No.* 4, 303–6 (1955) In German.

Using a simplified model to take account of the viscosity of the wall material, the equations for the propagation of a rectangular pulse are integrated using Laplace-transforms. J. E. CAFFYN

CAPILLARITY 532.6

532.6 : 536.7

8539. Arbitrary choice of the dividing surface in capillary layers not in equilibrium. II. R. DEFAY. *Bull. Acad. Roy. Belgique Cl. Sci.*, **41**, *No.* 6, 653–65 (1955) In French.

Out of equilibrium, the use of a Gibbs dividing surface implies three assumptions. The first two were discussed in the previous part [Abstr. 5253 (1955)] The present paper examines the conditions of applicability of the third assumption to each arbitrary dividing surface. These conditions are always satisfied in the case of equilibrium. Out of equilibrium the dividing surface is not arbitrary, except in a few particular cases. For the pure dynamical surface tension (surface layer of the same composition as the solution) the relations may be applied without appreciable error to the dividing surface so placed as to make the adsorptions vanish. A.

532.68

8540. Thermodynamics of sorption by solids under finite strain with particular reference to fibers. H. J. WHITE, JR. *J. chem. Phys.*, **23**, *No.* 8, 1491–8 (*Aug.*, 1955).

Equations have been derived expressing the conditions of equilibrium for a strained solid absorbent in contact with fluid absorbates. The results are more general than any previously derived and are not limited to infinitesimal strains or isotropic absorbents; it is necessary that the principal axes of stress and of strain coincide. The results are applied to a few cases involving various states of strain in fibrous absorbents such as might be encountered in the textile industry. One result was obtained which was uniquely different from the usual thermodynamic relations involving hydrostatic pressure. Essentially, three different forms of Gibbs free energy appear. These differ in accordance with the way in which the extensive variable for the absorbent was defined. A.

MOLECULAR THEORY OF LIQUIDS 532.7

532.7

8541. Theory of the zone structure of a three-dimensional model of a liquid. A. I. GUBANOV. *Zh. éksper. teor. Fiz.*, **28**, *No.* 4, 401–8 (1955) In Russian.

The perturbation method previously applied to a one-dimensional disordered chain of atoms [Abstr. 8087 (1954)] is now applied to a distorted crystal lattice, specified by a non-Euclidean metric, the metric tensor being a random function of the lattice points. There is no essential difference between the present and the previous paper with regard to method of deduction and result. R. EISENSCHITZ

532.7

8542. Hydrodynamic frictional and diffusion coefficients in idealized liquids. I. The collisional contribution. F. C. COLLINS AND H. RAFFEL. *J. chem. Phys.*, **23**, *No.* 8, 1454–60 (*Aug.*, 1955).

The approximate method of calculation of the collisional contribution to transport properties in liquids presented in an earlier paper is now extended to the calculation of the similar contribution to the frictional and diffusion coefficients. For the special case where the diffusing molecule is large compared to its neighbours, the calculated collisional contribution to the frictional coefficient is in good agreement with Stokes's law and the Langevin equation of colloid statistics is valid. However, for small diffusing molecules, the calculated frictional coefficient is not independent of the velocity of the given molecule. Numerical diffusion coefficients using molecular parameters obtained from sonic velocity data are about three times the experimental values as might be expected from the corresponding behaviour of the calculated viscosity coefficient contribution previously reported. In spite of the failure of the Stokes equation for the frictional coefficient of small molecules, the Stokes–Einstein equation represents fairly satisfactorily the case of self-diffusion. This is due to the averaging over all velocities of the diffusing molecule. A.

532.7 : 541.64

8543. Intrinsic viscosity–molecular weight relationship of high polymers: a new equation. S. R. PALIT. *Indian J. Phys.*, **29**, 65–80 (*Feb.*, 1955).

Based on Eyring's rate theory and the "hole" theory of liquids the following equation, correlating the intrinsic viscosity, $[\eta]$ and molecular weight of polymers has been derived: $100\rho_0[\eta] = K_1 M^{2/3} - \ln M + K_2$, where ρ_0 is the density of the polymer at infinite dilution and K_1 and K_2 are constants. All existing data have been found to be in agreement

with this equation. The modified Staudinger equation, $[\eta] = KM^{\alpha}$, which is in common use, is shown to be a special case of this equation and cases are cited where the latter equation is found to be invalid, whereas the new equation is found adequate. Critical tests based on differential $[\eta]$ in two solvents for the same polymer have been devised and it is conclusively demonstrated that the modified Staudinger equation leads to inconsistent results and is untenable, whereas the new equation is in conformity with experimental facts. A.

532.72

8544. Resistance in a liquid–liquid interface. III. The effect of molecular properties. J. H. SINFELT AND H. G. DRICKAMER. *J. chem. Phys.*, **23**, *No.* 6, 1095–9 (*June*, 1955).

The diffusion of molecular sulphur across a saturated liquid–liquid interface has been investigated for several molecular pairs, using a method previously described [Abstr. 115, 2469–70 (1952)]. The interfacial resistance does not directly depend on polarity of the liquids, nor can it be correlated with interfacial tension. High resistances are associated with liquids which show a high degree of hydrogen bonding. With suitable assumptions it is possible to calculate a free energy of activation for transfer across the interface. It appears that transfer in systems involving negligible resistance is analogous to van der Waals's adsorption, while for systems involving high resistance the process is comparable to chemisorption. A.

532.73

8545. Shape of the consolute curve and its consequences for the theory of binary liquid mixtures of nonelectrolytes. F. KOHLER. *J. chem. Phys.*, **23**, *No.* 8, 1398–404 (*Aug.*, 1955).

The experimental results on the shape of the consolute curve of binary liquid mixtures with components A and B, especially the cubic dependence of the concentration on temperature, imply certain peculiarities in the behaviour of the excess free energy of mixing ΔG_{exc}. The term ΔG_{exc} is expressed as $W.x(1-x).\psi(x)$. Here $2W$ can be considered as the change in free energy, times Avogadro's number, when z contacts A–A and z contacts B–B are changed into $2z$ contacts A–B; x is the molefraction of one component, and z the co-ordination number. Moreover, $\psi(x)$ is much more sensitive than ΔG_{exc}, and has a theoretical significance, being proportional to the ratio of the number of A–B contacts in the system investigated to their number in a perfect solution if the assumptions of the strictly regular model are regarded as valid. With the assumption that the system is symmetrical, the consolute curve consists of the points at which the first derivative of ΔG_m with respect to x vanishes. If the function ψ is expressed as a power series in $s = 2x - 1$, one also obtains $T_c - T$, T_c being the critical temperature, as a power series in s. The experimental results on the consolute curves serve now to determine the coefficients of the power series, by which ψ is given. Two additional assumptions are needed: (1) The coefficients of the high powers vanish in order to make use of the relation $\psi(1) = 1$ and (2) the value of ΔG_{exc} for $T = T_c$ and $x = 0{\cdot}5$ is known approximately. With these assumptions the experimentally established flatness of the consolute curves leads to a curve for ψ *v.* x having a double-maximum ψ being greater than unity for high values of s, i.e., for great dilution of one component. This confirms earlier conclusions drawn from vapour pressure measurements and investigations of the volume change on mixing. From a molecular point of view one can express this result by saying that the solvation of the diluted component is increased as compared to a perfect solution, even if the mixture is so strongly endothermic as to separate into two phases. The theoretical interpretation is not yet clear. A.

532.785

8546. Time lag in spontaneous nucleation due to non-steady state effects. F. C. COLLINS. *Z. Elektrochem.*, **59**, *No.* 5, 406–9 (1955).

The non-steady-state problem in nucleation is treated by an approximate method, the form of which parallels the analogous problem in heat conduction. A lower bound for the relaxation time required to build up the steady-state concentration of embryos is obtained which turns out to be independent of the critical nucleus. The results are of interest in nucleation in viscous solutions and in other crystallization processes. A.

MECHANICS OF GASES 533

533.15

8547. How to deduce the true diffusivity from the measurement of the diffusion of a substance. Transposition by thermo-kinetics. P. VERNOTTE. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 26, 2522–4 (*June* 27, 1955) In French.

533.5 : 531.788.7 : 621.317.39

8548. Oscillographic measurement of the Penning-gauge characteristics. M. VARIČAK AND B. VOŠICKI. *J. sci. Instrum.*, **32**, *No.* 9, 346–8 (*Sept.*, 1955).

To investigate the performance of a Penning-type vacuum gauge, deflections proportional to its current were displayed on an oscilloscope screen, while the magnetic field in the gauge was linearly varied. Such a field was produced by an electromagnet, which was part of a linear time-base circuit. From the patterns observed at different pressures and voltages across the gauge, best working conditions could be quickly obtained. A.

533.56

8549. Investigations on mercury diffusion pumps made of glass. III. M. REICHARDT. *Z. angew. Phys.*, 7, *No.* 6, 297–301 (*June*, 1955) In German.

For Pt II, see Abstr. 7180 (1954). Pumping speed and fore vacuum stability in single and multi-stage mercury diffusion pumps made of glass (of the G. C. Mönch type) were investigated and a series of results, valid within certain limits, is given.

G. WITTENBERG

533.6.011 : 534.232

The influence of solid boundaries upon aerodynamic sound. *See Abstr.* 8567

533.6.011.31

8550. High-speed rotating cylinder for rarefied gas dynamics research. G. J. Maslach and J. Frisch. *Rev. sci. Instrum.*, **26**, *No.* 8, 751–4 (*Aug.*, 1955).

Recent interest in slip-flow phenomenon as applied to high-altitude supersonic flight problems has revived experimental activity aimed at determining slip-flow boundary conditions and evaluating empirical reflection and accommodation coefficients. A unique rotating cylinder apparatus has been designed and constructed for studies involving rarefied gas-surface interactions over a wide range of flow characteristics extending from continuum conditions to the free molecular flow region. In addition to the above studies the equipment can be used to generate a shear flow field essential to the development of instrumentation necessary for the measurement of rarefied gas flow boundary layers and other non-uniform flow conditions. The flow requirements and design considerations which govern the geometry of the system, the choice of vacuum pumping equipment, vacuum instrumentation, and the controlled speed centrifuge drive mechanism are discussed. The remotely controlled floating torsion balance system is described and the mechanical precision of the entire equipment is indicated. A.

533.6.013.22 : 534.232

Note on the emission of noise by supersonic jets. *See Abstr.* 8568

MOLECULAR THEORY OF GASES 533.7

533.7

8551. Contribution to the study of transport phenomena in gases at high densities. A. Michels, J. A. M. Cox, A. Botzen and A. S. Friedman. *J. appl. Phys.*, **26**, *No.* 7, 843–5 (*July*, 1955).

The results of recent measurements of the viscosity and thermal conductivity of argon have shown the importance of studying these transport phenomena over a large density range in different regions of the reduced temperature. It appears that the Chapman–Enskog theory cannot give an adequate description of the new experiments. It has not yet been possible to give a full account of the observations. However, a less rigorous theoretical discussion demonstrates the relevant physical features of the problem. For the moment it serves to indicate a new experimental programme. This research may contribute to a more clear understanding of the transport properties in different states of a material, including the difficult intermediate region between the gas and liquid state. A.

533.7

8552. Transport properties of gaseous hydrocarbons. J. D. Lambert, K. J. Cotton, M. W. Pailthorpe, A. M. Robinson, J. Scrivins, W. R. F. Vale and R. M. Young. *Proc. Roy. Soc. A*, **231**, 280–90 (*Aug.* 22, 1955).

Measurements have been made, at temperatures between 35 and 100°C, of the viscosities and thermal conductivities of gaseous methane, ethane, ethylene, propane, propylene, *cyclo*-propane, *n*-butane, *cis*-2-butene, *trans*-2-butene, 1 : 3-butadiene, *iso*-butane, *n*-pentane, *iso*-pentane, *neo*-pentane, *cyclo*-pentane, *n*-hexane, *neo*-hexane, *cyclo*-hexane, benzene, *n*-heptane, 2 : 4-dimethyl-pentane, *n*-octane, 2 : 3 : 4-trimethyl-pentane and of carbon tetrafluoride. Viscosities were measured by observing the damping of a pendulum swinging in the vapour and by a capillary-flow viscometer. Thermal conductivities were measured by the hot-wire method. The observed values of the ratio between the transport properties are discussed in the light of the kinetic theory of gases. It is found that highly flexible molecules show systematically lower values of the ratio, k/η, than other molecules, and it is suggested that this is due to a special type of intermolecular collision, involving some degree of intercoiling of the two molecules. This view is relevant to the interpretation of recent work on the vibrational activation of the ethylene molecule by collision with other hydrocarbons, and on the kinetics of the thermal decomposition of gaseous hydrocarbons. Inferences can also be drawn about the ease of interchange of translational energy with vibrational and with rotational energy in collisions; these are discussed in relation to information obtained from ultrasonic dispersion measurements. A.

533.7 : 536.7

8553. "Virial theorem" for the flow of energy. R. Eisenschitz. *Phys. Rev.*, **99**, *No.* 4, 1059–61 (*Aug.* 15, 1955).

Expressions are obtained for the flow of energy and momentum in assemblies of densely packed molecules, using a generalized virial theorem. They differ to some extent from expressions put forward by previous authors who had only derived the divergence of the flow vectors. Classical results are shown to be valid also in quantum mechanics. A.

533.7 : 539.13

8554. Thermal diffusion of gas mixtures and determination of force constants. S. C. Saxena. *Indian J. Phys.*, **29**, *No.* 3, 131–40 (*March*, 1955).

The value for the force constant ε_{12} has been calculated from the observed variation of thermal diffusion factor with temperature to a higher approximation than before. These ε_{12} values have been combined with binary viscosity and inter-diffusion data to calculate r_{12}. Utilizing these values of the force constants the thermal diffusion factor has been calculated for a number of binary gas mixtures and compared with the experimental data. It is found that the agreement between theory and experiment is quite satisfactory, A.

VIBRATIONS . ACOUSTICS 534

534.121.1

8555. Vibration of a square plate point supported at midpoints of sides. H. L. Cox. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 4, 791–2 (*July*, 1955).

An approximate solution is presented for the fundamental frequency of flexural vibration of a uniform elastic square plate that is point-supported

at the midpoints of the sides; otherwise, the boundaries of the plate are free. The solutions are valid for plates which have a value of Poisson's Ratio of 0·3. A.

534.13

8556. On the representation of the types of motion of a free, linear oscillating system with two degrees of freedom. K. AUCH AND W. BRAUNBEK. *Ann. Phys.* [*Leipzig*] **15,** *No.* 5–6, 255–67 (1955) In German.

Instead of regarding the motion as consisting of two superposed modes, it can be better described as a single, amplitude- and phase-modulated oscillation. The complex modulation amplitudes are plotted in the complex variable plane; from this, the real amplitudes of the two components of the system and their phase difference can be directly obtained. Extension of the method to non-linear coupled systems is feasible. A. GELBTUCH

534.133 : 537.228

8557. On the determination of electromechanical coupling coefficients in a polyresonant piezoelectric vibrator. E. A. G. SHAW. *Canad. J. Phys.*, **33,** *No.* 9, 504–8 (*Sept.*, 1955).

The well-known relationship between the electromechanical coupling coefficient and the separation (σ) of resonance and antiresonance frequencies requires modification where several significant modes occur within a small frequency interval. An expression is given for the "true" values of σ (i.e. those which would arise if each mode existed alone) in terms of the many moded system. The analysis neglects mechanical and electrical losses. A.

534.141.3

8558. The effect of bow speed and pressure on the vibration speed of catgut strings. B. BLADIER. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 19, 1868–71 (*May* 9, 1955) In French.

Vibration speed recorded in the centre point of the vibrating part of a string allows the evaluation of the upper harmonics appearing as undulations of the main wave diagram. A catgut string CC tuned to 66 c/s and observed under a bow moved at constant speed but with increasing pressure, will display undulations of growing amplitudes the number of which, however, will remain unchanged. On the whole, increase of bow pressure enriches the timbre. The increase of bow speed at constant pressure will result in a steeper rise and fall and in an increased composite amplitude of the main wave, without affecting the number, the shape and the amplitude of partial undulations substantially. J. C. STARK

534.213.4

8559. Acoustical propagation of higher order modes in the region of cutoff. R. F. LAMBERT. *J. Acoust. Soc. Amer.*, **27,** *No.* 4, 790–1 (*July*, 1955).

Experimental data on the amplitude of transverse particle velocity associated with the (1, 0) mode of rectangular tube for frequencies in the region of cutoff are presented. The distance decay from the source is exponential for frequencies investigated in the range $f/f_c \leqslant 0{\cdot}998$ where f is the frequency of excitation and f_c is the mode cutoff frequency. At cutoff, the amplitude drops to the fraction $1/e$ of its value at the source over a distance interval equal to about 8 times the tube width. For frequencies above $f/f_c = 1{\cdot}01$ the progressive wave pattern appears fully developed. Comparison data between theoretical and measured values of attenuation for frequencies below cutoff are also presented. A.

534.22/.23

8560. The velocity and attenuation of sound in solid argon. E. W. GUPTILL, C. K. HOYT AND D. K. ROBINSON. Letter in *Canad. J. Phys.*, **33,** *No.* 7, 397 (*July*, 1955).

A cylindrical ceramic tube containing solid argon is acoustically insulated to form two vertical half-cylinders employed as an acoustical transmitter and receiver respectively against the inner surface as a common ground. Sound velocities are calculated from resonance frequencies at which maximum response occurs, although the high attenuation of sound in solid argon makes these measurements difficult. J. C. STARK

534.22

8561. Pressure dependence of ultrasonic velocity in sea water. E. H. CARNEVALE AND T. A. LITOVITZ. Letter in *J. Acoust. Soc. Amer.*, **27,** *No.* 4, 794–5 (*July*, 1955).

Velocity measurements at pressures up to 1 900 kg/cm^2 in artificial sea water show no significant difference to the behaviour of distilled water.

T. C. TOYE

534.222.2

8562. Measurement of wall temperature and heat flow in the shock tube. A. J. CHABAI AND R. J. EMRICH. Letter in *J. appl. Phys.*, **26,** *No.* 6, 779–80 (*June*, 1955).

Wall temperature was measured by a gold foil resistance thermometer, consisting of a gold foil 3×10^{-6} in. thick mounted on $1{\cdot}5\times10^{-3}$ in. thick linen paper and embedded with thermosetting resin in a groove 8×10^{-3} in. deep in the tube wall. The foil takes up the surface temperature in less than 1 μsec. Preliminary experiments show that the wall temp. increases in the rarefaction zone following a shock front, even though the gas temp. and stagnation temp. in this region are, on idealized theory, below the wall temp.; this demonstrates the possible importance of frictional heating of the boundary layer. A. SCHOFIELD

534.222.2

8563. Shock waves in air produced by waves in a plate. W. A. ALLEN, J. M. MAPES AND E. B. MAYFIELD. *J. appl. Phys.*, **26,** *No.* 9, 1173–6 (*Sept.*, 1955).

A shadowgraphic technique has been used to measure surface motion of a series of steel plates while they deform under impact caused by ½ in. dia. steel cylinders fired into their back surfaces at about 2 800 ft/sec. The strength of the air shock produced when an initial longitudinal wave in a plate strikes the free surface of the plate has been inferred from the measured shock wave velocity in the air. The shock strength has been related to particle velocity of the surface of the plate. The results are compared to previous work involving contact explosions of small charges on plates. A.

534.23 : 532.7 : 536.632

8564. Sound absorption in liquids in relation to their specific heats. S. PARTHASARATHY AND D. S. GURUSWAMY. *Ann. Phys.* [*Leipzig*] **16**, *No.* 1–2, 31–42 (1955).

A new expression for the sound absorption in liquids as observed at 3 Mc/s and above has been derived on the basis of the relation which has been observed to exist between the ratio of specific heats and the ratio of observed absorption to the classical absorption. The new formula can be denoted by

$$\frac{\alpha}{\nu^2} = \left(\frac{\frac{2}{3}}{\frac{5}{3} - \gamma}\right)^4 \left[\frac{8\pi^2}{3v^3\rho}\left(\eta + \frac{3}{4}\frac{\gamma - 1}{cp}\kappa\right)\right]$$

where the second term on the right side is due to Stokes and Kirchhoff. A.

534.231

8565. Disturbance of the sound field in the vicinity of a rigid sphere. O. BROSZE. *Elektron. Rdsch.*, **9**, *No.* 3, 112–17 (*March*, 1955) In German.

The author has calculated the curves of constant amplitude and constant phase in the neighbourhood of rigid spheres in a sound field in which the radii of spheres in terms of wavelength ($K = 2\pi/\lambda$), are $Ka = 0{\cdot}4$, 1, 4, 6, 8 and 10. The calculated values of sound pressure amplitude on radii making angles of 0, 30, 60, 90, 120, 150 and 180° with the incident sound, were found to agree within 5% of the observed values. It was shown that the increase of sound-pressure in front of the sphere $Ka = 10$ reach a value of $1{\cdot}97\times$ that in the undisturbed field—compared with $2\times$ in the case of an infinite plane rigid wall. A. B. WOOD

534.232

8566. Low-frequency tone-radiation demonstrator. D. W. MARTIN. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 4, 789 (*July*, 1955).

A description is given of a special device used by the author in demonstrating low-frequency tones (below 60 c/s). It consists of a 15 in. loudspeaker mounted in front of a bass-reflex cabinet which in turn is attached firmly to a platform containing a large exponential horn of low cutoff frequency. A. B. WOOD

534.232 : 533.6.011

8567. The influence of solid boundaries upon aerodynamic sound. N. CURLE. *Proc. Roy. Soc. A*, **231**, 505–14 (*Sept.* 20, 1955).

An extension is made to Lighthill's general theory of aerodynamic sound, so as to incorporate the influence of solid boundaries upon the sound field. This influence is twofold, namely, (i) reflection and diffraction of the sound waves at the solid boundaries, and (ii) a resultant dipole field at the solid boundaries which are the limits of Lighthill's quadrupole distribution. It is shown that these effects are exactly equivalent to a distribution of dipoles, each representing the force with which unit area of solid boundary acts upon the fluid. A dimensional analysis shows that the intensity of the sound generated by the dipoles should at large distances x be of the general form $I \propto \rho_0 U_0^6 a_0^{-3} L^2 x^{-2}$, where U_0 is a typical velocity of the flow, L is a typical length of the body, a_0 is the velocity of sound in fluid at rest and ρ_0 is the density of the fluid at rest. Accordingly, these dipoles should be more efficient generators of sound than the quadrupoles of Lighthill's theory if the Mach number is small enough. It is shown that the fundamental frequency of the dipole sound is one half of the frequency of the quadrupole sound. A.

534.232 : 533.6.013.22

8568. Note on the emission of noise by supersonic jets. H. P. KRAMER. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 4, 789–90 (*July*, 1955).

The sound produced in a supersonic jet issues predominantly at an acute angle θ to the direction of gas flow. This is reminiscent of the Cherenkov effect in which a charged particle passing through a medium at a speed v greater than the local speed c of propagation of electromagnetic waves, radiates light in a direction $\sec^{-1} v/c$. The author has applied this method of attack in the acoustical problem and shows that it is essentially equivalent to Lighthill's method [Abstr. 3372 (1952)] since it consists in replacing his quadrupole source distribution in the interior of the jet by the resultant surface pressure distribution.

A. B. WOOD

534.232 : 537.228.2

8569. Electrostriction in fluids and production of ultrasound by electrostrictive means. H. GOETZ. *Z. Phys.*, **141**, *No.* 3, 277–93 (1955) In German.

The literature on electrostriction in fluids is briefly reviewed and the theoretical basis for electrostrictive methods of producing ultrasound is described. A detailed description is given of equipment of the impulse type for studying electrostriction in fluids without interference from temperature changes set up in the fluid. Some results are quoted for certain organic liquids; these include a study of the progressive chemical changes which occur in nitrobenzol under the influence of an electric field. H. J. H. STARKS

534.26 : 535.81 : 666

8570. Ultrasonic diffraction patterns in some optical glasses. K. RAMAVATARAM. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 749–50 (*Sept.*, 1955).

Ultrasonic diffraction patterns obtained in four different optical glasses are described. It is found that each glass yields a characteristic pattern. The elastic and photoelastic constants of these glasses have been determined and an attempt has been made to connect them with the diffraction patterns. A.

534.322.3

8571. The sounds of impact of a solid on a liquid surface. E. G. RICHARDSON. *Proc. Phys. Soc. B*, **68**, *Pt* 8, 541–7 (*Aug.*, 1955).

The sounds, recorded on a microphone in air and on a hydrophone beneath the liquid, when a solid body strikes the surface are recorded and correlated with ciné-photographs of the cavity formed on entry. Measurements of base pressure on a projectile forming a cavity are also made. It appears that the major contribution to the sound comes from pulsations of the cavity. A.

534.61 : 534.232 : 535.324

8572. Ultrasound output of a quartz oscillator in various liquids by an optical method. S. PARTHASARATHY, M. PANCHOLY AND C. B. TIPNIS. *Z. Phys.*, **142**, *No.* 1, 14–20 (1955) In German.

An investigation of the high-frequency range necessary to produce the same variation in refractive

index, near the surface of the crystal, in different liquids. A study of the electrical energy required to produce the sound intensity shows that the output from the crystal depends upon the liquid in which it oscillates. T. C. TOYE

534.7

Physiological acoustics. Hearing. *See also under* "Medical science. Human physiology." Decimal classification 612.85

534.832 : 621.314.2

8573. Recent contributions to transformer audible noise control. W. B. CONOVER AND R. J. RINGLEE. *Trans Amer. Inst. Elect. Engrs III*, **74**, 77–90 (1955) = *Pwr Apparatus Syst., No.* 17 (*April*, 1955).

A comprehensive investigation into the use of models for solving noise problems, and of the technique of "sound cancellation." Practical investigations included field plots *v.* distance, variation of pressure with azimuth angle and pressure build-up inside a four-walled barrier. Attenuation by 2- and 3-wall barriers may be predicted by simple calculation, but the 4-wall barrier data did not correlate with wall height or spacing from the tank. Theoretical investigations included "Requirements for scaling structures," "Sound pressure field at a large distance from a sound source of arbitrary shape," "Spherical model approximation to a transformer tank," "Sound pressure field at a large distance from two point sources," "Approximate expression for the resonant frequencies of oil-backed plates." The method of "sound cancellation" using loudspeakers was investigated theoretically and in field tests on a 15 MVA unit. Reductions of 6 db were obtained over angles up to 35°. At given points 20 db was easily obtainable.

M. WATERS (R)

534.844 : 621.396.712.3 : 621.395.625.3

8574. Artificial reverberation. P. E. AXON, C. L. S. GILFORD AND D. E. L. SHORTER. *Proc. Instn Elect. Engrs, Paper No.* 1796 R, publ. *Feb.*, 1955 (**102B**, 624–42).

Republication, with discussion, of the paper abstracted in Abstr. 3528 (1955).

534.862.3 : 621.395.625

8575. The subjective discrimination of pitch and amplitude fluctuations in recording systems. A. STOTT AND P. E. AXON. *Proc. Instn Elect. Engrs, Paper No.* 1874 R, publ. *Sept.*, 1955 (**102B**, 643–56).

Deals with the measurement of subjective thresholds of the unwanted pitch and amplitude fluctuations which occur in the reproduced output of all types of sound recording systems. The pitch fluctuations are commonly known as "wow" or "flutter," and new equipment is described for generating controlled fluctuations of this type in musical or other programme signals. The threshold measurements thus made possible are more realistic than those hitherto available, which have been related only to frequency fluctuations in test tones. The generation and threshold measurement of controlled amplitude fluctuations are also described, since amplitude and frequency fluctuations commonly occur together. The results obtained enable frequency weighting characteristics to be defined which can be incorporated into instruments measuring the magnitude of the unwanted amplitude and frequency fluctuations in practical systems. It is shown that such instruments may then approximate to an ideal, subjectively weighted measuring device which, when threshold value is reached, will give the same indication irrespective of the type and frequency of the fluctuation measured. A.

OPTICS . RADIATION . SPECTRA 535

535.241

8576. Light units (draft of new standard). P. M. TIKHODEEV. *Svetotekhnika, No.* 1, 8–11 (1955) In Russian.

The new standard is based on the lumen and the MKS system of units. W. R. STOKER

535.241

8577. Primary photometric standard and the theory of dimensions. M. ESKENAZI. *Helv. phys. Acta*, **28**, *No.* 4, 395–402 (1955) In French.

The author considers that the system of photometric quantities needs the introduction of a new fundamental magnitude based on a receptor which responds to radiation in the same way as the defined "average eye." The full-radiator form of primary standard cannot serve as a satisfactory basis for the new magnitude; the system of measurements based on it is "under-dimensioned." J. W. T. WALSH

535.241.44

8578. The calculation of equivalent brightness. S. G. YUROV. *Svetotekhnika, No.* 2, 3–5 (1955) In Russian.

535.317.3/.4

8579. Simultaneous correction of meridian aberrations. Errata and notes. F. A. LUCY. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 8, 670 (*Aug.*, 1955).

See Abstr. 4497–8 (1955).

535.317.6

8580. The determination of an optimum lens system. F. WACHENDORF. *Optik*, **12**, *No.* 8, 345–59 (1955) In German.

A continuation of previous work [Abstr. 7815 (1955)]. The difference equations connecting circle of confusion and lens parameters can be used to determine an optimum design. Some of the difficulties of procedure are discussed and the general problem of distinguishing the true optimum from other stationary values is considered. R. W. FISH

535.317.6

8581. Contributions on optical images. I. S. MOHOROVIČIĆ. *Optik*, **12**, *No.* 8, 360–1 (1955) In German.

A simple geometric construction is shown, which can be used to determine general relationships between conjugate points providing one pair is known.

R. W. FISH

535.317.6

8582. Petzval sum of thick lenses. J. L. RAYCES. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 9, 774 (*Sept.*, 1955).

The Herzberger method for the replacement of a thin lens by a thick lens having the same power and the same ratio between radii is shown to introduce

changes to the Petzval sum. These arise from the neglecting of higher powers of the thickness at too early a stage in the calculation. R. W. FISH

535.322.4

8583. A differential refractometer of high sensitivity. P. G. GUEST. *Austral. J. Phys.*, **8**, *No.* 2, 212–23 (*June*, 1955).

The refractometer is of the Jamin type. The positions of the main and fiduciary fringes are determined by means of a pair of photomultiplier tubes, the outputs of which are fed to a balanced amplifier. A change in optical path of 1/15 000th of a fringe can be detected, and the instrument is stable to within 1/5 000th of a fringe over 30 min periods. Examples are given of its use in the measurement of small differences in refractive index for liquids and gases. A.

535.33/.34

8584. The properties of fine virtual slits formed by oblique reflection at cylindrical surfaces. A. H. MCILRAITH. *Proc. Phys. Soc. B*, **68**, *Pt* 9, 649–56 (*Sept.*, 1955).

A theoretical and experimental examination of a virtual slit formed by reflection at a convex circular cylinder suggests that it is well suited for use as an entrance slit in spectroscopy. An expression for the aberration of the reflected wave front is found by making use of the properties of the virtual caustic. Measurements made on the wave front with a Lloyd mirror are in agreement with this expression. For a given tolerance on the aberration, the upper limit to the radius of the cylinder that can be used is inversely proportional to the cube of the angular aperture over which the reflected light is collected, and is from ten to twenty wavelengths for an aperture of 60°. The image is always rectangular; it follows precisely the much greater movements of the source slit and can thus be opened symmetrically even at widths of the order of one wavelength. Its brightness is from 10 to 20% lower than that of the source. Attention is drawn to its use as a curved slit and to its advantages over conventional slits at widths approaching a wavelength. A.

535.33.03

8585. Different practical designs for sliding sparks for spectrography in the far ultraviolet. J. ROMAND AND G. BALLOFFET. Letter in *J. Phys. Radium*, **16**, *No.* 6, 489–90 (*June*, 1955) In French.

Improvements on an earlier design [Abstr. 6374 (1952)] with the spark started by passage over an aluminium surface. G. F. LOTHIAN

535.33.03

8586. Cyanogen–oxygen flame as a spectrochemical source. M. R. BAKER AND B. L. VALLEE. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 9, 773 (*Sept.*, 1955).

This very hot flame, with a theoretical maximum temperature of 4 835°K, is much better than other flames, such as the oxy-hydrogen flame, for exciting lines of elements with high excitation potentials. Lines of Ag, Al, Ba, Ca, Co, Cr, Cu, Fe, Mg, Mn, Ni, Pb and Sr were recorded in 4 min on a 7-ft grating using less than a μg of each element. A. G. GAYDON

535.33.07

8587. Grating spectrographs in use at the P.C.B. infrared laboratory. G. AMAT. *Rev. Opt.*, **33**, *No.* 12, 642–4 (*Dec.*, 1954) In French.

535.33.07

8588. Luminosities compared for prism and grating spectrometers. P. JACQUINOT. *Rev. Opt.*, **33**, *No.* 12, 653–8 (*Dec.*, 1954) In French.

535.33.07

8589. On the separation of spectra of different orders of a grating at grazing incidence in the far ultraviolet. N. ASTOIN, B. VODAR AND J. ROMAND. Letter in *J. Phys. Radium*, **16**, *No.* 6, 491–2 (*June*, 1955) In French.

An Al mirror used at 45° incidence before the slit effectively removes wavelengths less than about 300 Å. G. F. LOTHIAN

535.33.07

8590. Auxiliary optical system for measurement of the infrared transmittance of flat plates with the Perkin–Elmer 12-C spectrometer. J. R. JENNESS, JR. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 8, 671 (*Aug.*, 1955).

With a flat plate placed in front of the entrance slit, the image of the source suffers a change in focus and at oblique incidence may be displaced laterally. An auxiliary system of spherical and plane mirrors overcomes this defect, and has been shown to give accurate results at incident angles up to 85°. R. W. FISH

535.33.07

8591. New recording spectrophotometer. B. S. PRITCHARD AND W. A. HOLMWOOD. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 690–5 (*Sept.*, 1955).

In the redesign of the General Electric Recording Spectrophotometer many improvements have been made affecting its performance, versatility and convenience. For example, new monochromator slit width ratios result in a twofold increase in light transmission, and other optical changes further increase the sensitivity. Among other improvements described are smaller size, faster speed of operation, and greater serviceability. A.

535.33.07 : 535.375.5

8592. High-current mercury arc Raman source. E. R. SHULL. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 8, 670–1 (*Aug.*, 1955).

A low-pressure, water cooled mercury arc lamp is described which produces very intense mercury lines and very weak background continuum at high operating currents. The gain in intensity is said to be particularly valuable for making good polarization measurements on Raman lines. R. W. FISH

535.33.07 : 778.392

8593. The photographic reproduction of spectral lines. H. MOSER. *Optik*, **12**, *No.* 8, 362–76 (1955) In German.

The intensity distribution in the image given by a spectrograph is seriously affected by the properties of the photographic emulsion when it is recorded. Comparison of distributions measured photoelectrically and recorded photographically allow the emulsion properties to be determined. From the variation of the emulsion constants with wavelength

and emulsion thickness, the limitations of a photographic plate as a recording medium are deduced.

R. W. FISH

535.331

8594. Isotope shifts in the spectrum of helium. A. P. STONE. Letter in *Nature* [*London*] **176,** 130 (*July* 16, 1955).

Nuclear motion is found to account almost completely for the isotope shift in He; accurate wavefunctions must be used in evaluating the effect.

G. E. BROWN

535.332

8595. A new phenomenon associated with active nitrogen. C. R. STANLEY. *Proc. Phys. Soc. A,* **68,** *Pt* 8, 709–16 (*Aug.*, 1955).

An orange beam, obtained with the author's active nitrogen apparatus [Abstr. 10932 (1954)], is considered to constitute a nitrogen afterglow. Its spectrum is compared with the exciting arc spectrum over a range of pressure and current. The decay is exponential, with a mean life of the order of 10^{-4} sec. Other physical and chemical properties are briefly discussed. A.

535.332–32

8596. Continuous emission spectra of rare gases in the vacuum ultraviolet region. Y. TANAKA. *J. Opt. Soc. Amer.*, **45,** *No.* 9, 710–13 (*Sept.*, 1955).

Using an ordinary transformer discharge, continuous emission spectra of krypton and argon similar to that of xenon reported recently were found in the regions from their resonance lines to about 1 850 and 1 650 Å, respectively. The characteristics of all the rare gas continua were similar regarding their dependence on excitation conditions as well as their features. The origin of these continua is explained by a process similar to that for the xenon continuum. The helium and neon continua are briefly discussed in connection with the present work. A.

535.333

8597. The emission spectrum of AlF in the region 1 700–2 000 Å. S. M. NAUDÉ AND T. J. HUGO. Note in *Canad. J. Phys.*, **33,** *No.* 9, 573–4 (*Sept.*, 1955).

The systems $B^1\Sigma^+$, $C^1\Sigma^+ - X^1\Sigma^+$ were photographed in emission. Vibrational analyses lead to the following constants:

$$\nu(B-X) = 54\,249{\cdot}6 + (864{\cdot}8\,u' - 7{\cdot}23\,u'^2 + 0{\cdot}009\,u'^3) - (799{\cdot}2\,u'' - 4{\cdot}74\,u''^2 + 0{\cdot}015\,u''^2),$$

$$\nu(C-X) = 57\,682{\cdot}2 + (934{\cdot}3\,u' - 5{\cdot}18\,u'^2) - (799{\cdot}0\,u'' - 4{\cdot}74\,u''^2).$$

[See Abstr. 1156, 4346, 6492 (1954).] R. F. BARROW

535.333

8598. The triplet band systems of aluminium monofluoride. P. G. DODSWORTH AND R. F. BARROW. *Proc. Phys. Soc. A,* **68,** *Pt* 9, 829–35 (*Sept.*, 1955).

The vibrational analyses of three triplet band systems of aluminium monofluoride obtained in emission have been carried out. They arise from transitions from three $^3\Sigma$ states to a common lower $^3\Pi$ state. The order of the sub-levels of the $^3\Pi$ state and of the corresponding state for BF is considered. The relative position of the triplet and singlet levels for AlF is predicted. A.

535.333

8599. New band systems of MnF and MnBr in the red. W. HAYES AND T. E. NEVIN. *Proc. Phys. Soc. A,* **68,** *Pt* 8, 665–9 (*Aug.*, 1955).

New band systems attributed to MnF and MnBr have been observed in a hollow cathode discharge. The MnBr bands degraded to shorter wavelengths consist of two sequences of double headed bands in the region λ6285 Å–λ6246 Å. The MnF bands degraded to longer wavelengths, each band with four heads, comprise five sequences between λ7300 Å and λ6230 Å. It is suggested that both systems are due to a transition of the type $O^{\pm} - {}^5\Sigma^+$. A.

535.333

8600. The spectrum of MnBr in the photographic infra-red. W. HAYES. *Proc. Phys. Soc. A,* **68,** *Pt* 8, 670–4 (*Aug.*, 1955).

High dispersion spectrograms have shown the existence of two new band systems of MnBr in the region λ8850 Å–λ9700 Å. The bands in both systems are degraded to longer wavelengths. The shorter wavelength system is double headed and is considered to be the analogue of the Π–Σ system observed in MnCl. The longer wavelength system is single headed and is attributed to a Σ–Σ transition. Both systems show an isotope effect which confirms the vibrational analysis. A.

535.333

8601. Green and orange band spectra of CaOH, CaOD and calcium oxide. A. G. GAYDON. *Proc. Roy. Soc. A,* **231,** 437–45 (*Sept.* 20, 1955).

The green and orange flame bands have also been obtained in a "vacuum" arc in water vapour and heavy-water vapour. An isotope shift has been observed, supporting James and Sugden's assignment of the flame bands to CaOH. Absence of additional bands from an arc in mixed H_2O and D_2O eliminates $Ca(OH)_2$. The fine and gross structure of the CaOH and CaOD bands is described and discussed; the molecule is non-linear; the excitation process is believed to be thermal rather than chemiluminescent. These flame bands are not the same as the green and orange bands obtained with calcium salts in an arc in air. These latter are probably due to an oxide, but their structure is too complex for them to be due, as has been suggested, to transitions between singlet electronic states of CaO. It is possible that they may be due to transitions between triplet states of CaO, but under large dispersion the structure is so very complex that a polyatomic emitter appears more likely, and the dimer Ca_2O_2 is favoured. The relevance of these results to determinations of the dissociation energies of alkaline earth oxides, to the use of the bands in spectro-chemical analysis and to the absence of CaO bands from stellar spectra is discussed. A.

535.333

8602. Vibrational analysis of the emission spectrum of coronene as a forbidden transition. J. W. SIDMAN. Letter in *J. chem. Phys.*, **23,** *No.* 7, 1365–6 (*July*, 1955).

The vibrational analysis of the emission spectrum and the solvent effects on the emission spectrum of coronene both support the interpretation that the emission transition is forbidden by symmetry and is allowed by a degenerated vibration, as in benzene.

G. I. W. LLEWELYN

535.333

8603. The origin of the continuous emission spectrum of acetone. M. Fauris. *C.R. Acad. Sci.* [*Paris*] **241,** *No.* 2, 190–2 (*July* 11, 1955) In French.

A re-examination of the continuous emission, extending from about 2500 to beyond 5000 Å, of acetone excited in a Schüler tube. A brief discussion of certain previous experiments is given. No complete or final interpretation is suggested, but two electronic states of $\diagdown\!\!\diagup C=O$ provide a reasonable agreement with the observed intensity variation.

J. D. CRAGGS

535.333

8604. On a spectroscopic study of benzyl and benzol radicals ($C_6H_5\dot{C}H_2$ and $C_6H_5\dot{C}H$). H. Schüler and A. Michel. *Z. Naturforsch.*, **10a,** *No.* 6, 459–62 (1955) In German.

A general discussion of certain spectroscopic results obtained with excitation in a glow discharge positive column. Band structure, etc., is related to particular radicals in a characteristic manner. J. D. CRAGGS

535.333 : 535.343

8605. Absorption and emission spectra of bismuth-activated phosphors. W. A. Runciman. *Proc. Phys. Soc. A,* **68,** *Pt* 7, 647–9 (*July*, 1955).

From experimentally measured spectra for CaO–Bi and SrO–Bi phosphors it is suggested that the vibrational bands arise from the radially symmetrical movement of the six oxygen ions around the activator, the charge distribution changing from a spherical $6s$ to a dumbell $6p$ form on excitation. Good agreement is shown between theoretical and experimental formulae. G. F. J. GARLICK

535.338.4

8606. The identification of the band spectra of ionized molecules. K. Dressler. *Helv. phys. Acta,* **28,** *No.* 4, 317–18 (1955) In German.

NO, NS, PO and PS and their singly-charged positive ions are briefly discussed. A new analysis of the β-bands of PO leads to

$$\nu = \left.\begin{matrix}30\,841\cdot3\\30\,618\cdot7\end{matrix}\right\} + 1\,166\cdot2\,u' - 14\cdot10\,u'^2 - 1\,232\cdot5\,u'' + 6\cdot50\,u''^2$$

and $D_0''(\mathrm{PO}) = 5\cdot4\,\mathrm{eV}$. [See Abstr. 6893 (1955).]

R. F. BARROW

535.34.07 : 535.824.2

Reflecting objective for microspectroscopy. *See Abstr.* 8681

535.34.07 : 538.561

8607. The maser—new type of microwave amplifier, frequency standard, and spectrometer. J. P. Gordon, H. J. Zeiger and C. H. Townes. *Phys. Rev.*, **99,** *No.* 4, 1264–74 (*Aug.* 15, 1955).

A type of device is described which can be used as a microwave amplifier, spectrometer, or oscillator. Experimental results are given. When operated as a spectrometer, the device has good sensitivity, and, by eliminating the usual Doppler broadening, a resolution of 7 kc/s has been achieved. Operated as an oscillator, the device produced a frequency stable to at least 4 parts in 10^{12} in times of the order of a second, and stable over periods of an hour or more to at least a part in 10^{10}. The device is examined theoretically, and results are given for the expected sensitivity of the spectrometer, the stability and purity of the oscillation, and the noise figure of the amplifier. Under certain conditions a noise figure approaching the theoretical limit of unity, along with reasonably high gain, should be attainable. A.

535.343 : 537.311.33

Accurate measurements of absorption in indium antimonide and gallium antimonide. *See Abstr.* 8765

535.343 : 539.132

8608. Intramolecular charge transfer spectra observed with some compounds containing the nitro or the carbonyl group. S. Nagakura. *J. chem. Phys.*, **23,** *No.* 8, 1441–5 (*Aug.*, 1955).

A new method, which proved to be useful for the theoretical study of electron migration for the monosubstituted benzene molecule, is employed to interpret strong absorption bands observed with various unsaturated compounds containing the nitro or the carbonyl group. Consequently, it is shown that these absorptions correspond to the transition between two energy levels produced by the interaction of the highest occupied level of the electron donating group with the lowest vacant one of the electron accepting group, and that theoretical values of transition energies and oscillator strengths evaluated by use of the present method are in very good agreement with the observed values. Furthermore, the present interpretation of these absorptions is discussed in comparison with the earlier resonance viewpoint. A.

535.343 : 537.564

8609. Photoionization efficiencies and cross sections in NH_3. W. C. Walker and G. L. Weissler. Letter in *J. chem. Phys.*, **23,** *No.* 8, 1540–1 (*Aug.*, 1955).

Gives cross-sections for photoionization from 1231 ± 5 Å (ionization onset) to 687 Å. Absorption cross-sections and ionization cross-sections are respectively liable to errors of 5–10% and 15–20%. There is a brief discussion of the sudden rise in absorption at 824 Å. J. D. CRAGGS

535.343

8610. Absorption spectra of iodine and bromine in the gas phase and "inert" solvents. I. Iodine. D. F. Evans. *J. chem. Phys.*, **23,** *No.* 8, 1424–6 (*Aug.*, 1955).

The strong absorption of iodine dissolved in paraffin hydrocarbons in the region of 2200–2600 Å is not shown either by gaseous iodine or by iodine dissolved in perfluoroheptane (PFH) or di-perfluorohexyl ether, and is present only to a much smaller extent for iodine dissolved in chloroform. The interaction of iodine with *n*-heptane has been studied quantitatively in PFH solution. It is concluded that the above absorption is a charge transfer transition due to a very weak, or possibly collisional type, complex, and is not a solvent shift of the N–V transition of the iodine molecule. A.

535.343

8611. Absorption spectra of iodine and bromine in the gas phase and "inert" solvents. II. Bromine. D. F. Evans. *J. chem. Phys.*, **23,** *No.* 8, 1426–8 (*Aug.*, 1955).

The effect of foreign gases on the continuous absorption of bromine in the region 2200–5100 Å has been

studied. Contrary to the results of Bayliss and Rees, no increases in intensity were observed. The absorption of bromine in various inert solvents has also been measured. The results are similar to those obtained with iodine and have been interpreted in an analogous manner. No maxima were found at 2725 and 2500 Å for bromine dissolved in chloroform and cyclohexane, respectively, in disagreement with Aikin, Bayliss and Rees. A.

535.343

8612. Low resolution electronic spectrum of crystalline para-dimethoxybenzene with application to benzene. A. C. Albrecht and W. T. Simpson. *J. chem. Phys.*, **23**, *No.* 8, 1480–5 (*Aug.*, 1955).

The spectrum of a thin (0·37 μ) crystal of para-dimethoxybenzene for light incident on the 001 plane and polarized along the *a* and *b* crystallographic axes is given. From this, approximate spectra are determined for the two in-plane directions of the molecule. Absorption at 2900 Å is polarized predominately in a direction perpendicular to the line joining the substituents while absorption at 2350 Å is parallel to this line. The 2600 and 2000 Å absorptions in benzene are related respectively to the 2900 and 2350 Å bands in dimethoxybenzene and consequently the benzene bands are found to arise from transition to upper states of species B_{2u} and B_{1u} respectively. The relation to conventional orbital theory is briefly discussed. A.

535.343

8613. Perfluoroheptane as a spectroscopic solvent. D. F. Evans. *J. chem. Phys.*, **23**, *No.* 8, 1429–30 (*Aug.*, 1955).

Solvent shifts of ultraviolet absorption bands (relative to the gas phase) have been shown to be much less for perfluoroheptane than for *n*-heptane. The oscillator strength of the 2400 Å band of styrene has been measured in the gas phase and in perfluoroheptane and *n*-heptane solution. Small increases were observed in solution, which are, however, less than those calculated theoretically. A.

535.343

8614. Contribution to the study of the spectrum of the OH molecule. S. Benoist. *Ann. Phys.* [*Paris*] **10**, 363–76 (*May–June*, 1955) In French.

The rotation–vibration spectrum was taken of OH, prepared in a high-frequency discharge tube through which water vapour was flowing. The vibration and rotation constants were calculated. The intensity distribution was studied and showed that the spectrum was indeed due to neutral OH molecules. It was compared with a similar spectrum of OD. The ultraviolet OH spectrum showed three new bands which were identified as belonging to the system $A^2\Sigma - X^2\Pi$. A. J. TAYLOR

535.343

8615. The absorption spectrum of KCl crystals containing metallic thallium centres. J. Rohleder. *Bull. Acad. Polon. Sci. Cl.* 3, **3**, *No.* 4, 229–32 (1955).

Following photoelectric studies of KCl–Tl crystals [see Abstr. 4669 (1955)] measurements of absorption spectra were made on the crystals. Calculations of the number of Tl centres from absorption spectra agree with those for chemical analysis and indicate an atomic dispersion of the impurity. G. F. J. GARLICK

535.343

8616. Intrinsic optical absorption in single-crystal germanium and silicon at 77°K and 300°K. W. C. Dash and R. Newman. *Phys. Rev.*, **99**, *No.* 4, 1151–5 (*Aug.* 15, 1955).

The intrinsic absorption spectra of high-purity single-crystals were measured. The spectral regions studied encompassed a range of absorption coefficient from 0·1 cm^{-1} to 10^5 cm^{-1} for each material. The germanium data may be interpreted as indicating a threshold for direct translations at 0·81 eV at 300°K and at 0·88 eV at 77°K. The threshold for indirect transitions was placed at 0·62 and 0·72 eV for 300 and 77°K, respectively. For silicon the data were not as readily interpreted. However, there is an indication that the threshold for direct transitions should be placed at about 2·5 eV and the threshold for indirect transitions at 1·06 eV and 1·16 eV at 300 and 77°K, respectively. A.

535.343

8617. Vibrational spectra of SiH_3Br and SiH_2Br_2. D. W. Mayo, H. E. Opitz and J. S. Peake. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1344–5 (*July*, 1955).

Tables are given of the infrared spectra and band assignments, and of the thermodynamic functions between 275 and 1200°K. C. TURNER

535.343

8618. Fundamental frequencies of the NH_4^+-ion in crystallized ammonium fluoride. J.-P. Mathieu. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 26, 2508–10 (*June* 27, 1955) In French.

Measurements of Raman and infrared spectra on single crystals show that the symmetry of NH_4^+ is only C_3 or C_{3v} so that the four fundamental frequencies must be attributed to different lines from those proposed by Bovey [Abstr. 193 (1952)]. C. TURNER

535.343

8619. Infrared spectra of oxonium halides and the structure of the oxonium ion. C. C. Ferriso and D. F. Hornig. *J. chem. Phys.*, **23**, *No.* 8, 1464–8 (*Aug.*, 1955).

The monohydrates of the hydrogen halides exist as ionic crystals. The infrared spectra of OH_3F, OH_3Cl, OH_3Br, OH_3I and OD_3Cl at −195°C showed the four fundamental frequencies expected for a symmetrical pyramid at about 1100 cm^{-1} (ν_2), 1700 cm^{-1} (ν_4), 2600 cm^{-1} (ν_1 or ν_3), and 3200 cm^{-1} (ν_1 or ν_3). The high-frequency bands, which are very broad at −195°C, did not sharpen on cooling to 8°K, indicating their breadth is caused by some frozen-in disorder. A.

535.343

8620. Infrared spectrum of solid ammonium azide; a vibrational assignment. D. A. Dows, E. Whittle and G. C. Pimentel. *J. chem. Phys.*, **23**, *No.* 8, 1475–9 (*Aug.*, 1955).

Infrared spectra of solid ammonium azide at 68°K are presented. The solid, prepared by sublimation onto a cold salt window, seems to be a disordered crystal which becomes ordered on warming above 150°K. The annealed crystal displays spectral features with spacings of 10–20 cm^{-1} which can be attributed to crystal site perturbations. A band at 1830 cm^{-1} appears which is assigned as a combination involving

a lattice torsional motion of the ammonium ion ($420 \pm 20\,cm^{-1}$). A vibrational assignment of solid ammonium azide is made. The vapour over ammonium azide at room temperature contains predominantly hydrazoic acid and ammonia. A.

535.343 : 539.234

8621. Optical properties of cadmium sulfide and zinc sulfide from 0·6 micron to 14 microns. J. F. Hall, Jr and W. F. C. Ferguson. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 714–18 (*Sept.*, 1955).

The index of refraction and the absorption of evaporated films of CdS and ZnS in the spectral region from 0·6 to 14μ were determined from spectrophotometric reflectance and transmittance measurements. The index of refraction of CdS ranged from 2·52 at 0·6μ to 2·26 at 14μ and was independent of deposition rate. The index of ZnS varied from 2·34 at 0·6μ to 2·15 at 14μ and was independent of deposition rate. The absorption coefficient of CdS depended upon the deposition rate from 0·6 to 6μ and increased beyond 6μ independently of deposition rate. The absorption coefficient of ZnS was approximately 0·001 in the region of investigation. Approximate formulae are given for calculating the index of refraction and absorption from the reflectance and transmittance when the absorption is small. A method is given for preparing the phosphors that yields films for which the index of refraction is independent of the deposition rate. The crystalline structure was investigated by means of X-ray diffraction. A.

535.343

8622. Infrared absorption spectra of hexammine metal complexes. M. Kobayashi and J. Fujita. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1354 (*July*, 1955).

The infrared absorption spectra of hexammine Co (III), Cr (III) and Ni (II) complexes have been measured. The effects of co-ordination on the vibrations in the NH_3 group are discussed and the new bands which appear on complex formation interpreted. G. I. W. Llewelyn

535.343

8623. Absorption spectrum of polyethylene in the near infrared. K. Rossmann. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1355–6 (*July*, 1955).

Graphical and tabulated results are given and assignments of the observed bands tentatively made. G. I. W. Llewelyn

535.343 : 541.632

8624. Infra-red spectroscopic studies of rotational isomerism in the polymethylene halides. J. K. Brown and N. Sheppard. *Proc. Roy. Soc. A*, **231**, 555–74 (*Sept.* 20, 1955).

Infrared spectra between 450 and 1500 cm^{-1} are presented for a series of polymethylene halides in the liquid and crystalline solid states. The spectra are discussed in terms of the different rotational isomeric forms of these molecules. A comparison of the observed carbon–halogen stretching frequencies with those of the *n*-propyl halides is used to determine the configurations of the C—C—C—*X* groups (*X* = halogen atom). The analysis shows that the solid-state isomers of a number of the tri-, tetra- and pentamethylene halides have non-planar skeletal structures. Crystalline trimethylene iodide exists in two forms, one of which is metastable; it is concluded that the metastable form has a planar skeleton (symmetry C_{2v}) and the stable form a non-planar skeleton (symmetry C_2). The solid-state isomers of the decamethylene halides probably have a fully extended planar zigzag configuration. A.

535.343 : 539.132

8625. Hyperfine structure in the inversion spectrum of $N^{14}H_3$ by a new high-resolution microwave spectrometer. J. P. Gordon. *Phys. Rev.*, **99**, *No.* 4, 1253–63 (*Aug.* 15, 1955).

The hyperfine structure of the inversion spectrum of $N^{14}H_3$ has been re-examined with an ultra-high resolution spectrometer. Lines whose total width at half-maximum is 7 kc/s have been obtained in this spectrometer. Such narrow lines allow resolution of magnetic hyperfine structure caused by reorientation of the spins of the hydrogen nuclei. The new structure has been satisfactorily explained to within the experimental error of about 1 kc/s by considering the various interactions of the magnetic moments of the hydrogen nuclei with the molecular fields. The interaction energy of the nitrogen nucleus has been remeasured with higher resolution than was possible previously, and indications were found that $|eqQ|$ for the lower inversion state is larger by about 0·01% than that for the upper state. The sign of eqQ was directly determined to be negative. A theoretical treatment of the magnetic interactions has been made which is slightly different from that which has previously been used. The method allows some simplification of the form of the magnetic interactions. A.

535.343

8626. Absorption of microwaves and u.h.f. radiowaves in phenol, cyclohexanol and 1-bromo 2-chloroethane. D. K. Ghosh. *Indian J. Sci.*, **29**, *No.* 4, 161–6 (*April*, 1955).

The absorption of u.h.f. radiowaves in the range 250–800 Mc/s and 3·18 cm microwaves in phenol and cyclohexanol and the absorption of 3·18 cm microwaves in 1-bromo 2-chloroethane have been studied by the direct optical method by avoiding formation of stationary waves. Maximum absorption of 3·18 cm microwaves has been exhibited by phenol, cyclohexanol and 1-bromo 2-chloroethane at temperatures 80, 95 and 10°C respectively. In the case of phenol and cyclohexanol these absorption maxima are found to be due to rotation of the substituent OH group about an axis, which coincides in the case of phenol with the diameter of the benzene ring passing through the carbon atom to which the OH group is attached. In the case of 1-bromo 2-chloroethane the absorption maximum may be due to rotation of one-half of the molecule about the C–C axis. No absorption maxima have been observed in the case of phenol and cyclohexanol in the u.h.f. region, but there is indication of occurrence of peaks beyond 850 Mc/s and these are found to be due to rotation of the substituent OG group in the case of cyclohexanol and of the single molecule in the case of phenol. A.

535.345

8627. Absorption coefficients of nitric oxide in the vacuum ultraviolet. H. SUN AND G. L. WEISSLER. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1372–3 (*July*, 1955).

The absolute absorption of light in NO has been measured photometrically in the wavelength range 374–1 300 Å. Results are given figuratively and in tabular form. G. I. W. LLEWELYN

535.345

8628. Some optical properties of strontium titanate crystal. S. B. LEVIN, N. J. FIELD, F. M. PLOCK AND L. MERKER. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 737–9 (*Sept.*, 1955).

Clear, colourless macrocrystals of strontium titanate grown by flame fusion are isotropic, with refractive index varying from 2·37 at 0·7μ to 2·67 at 0·4μ, where they exhibit a sharp absorption edge corresponding to an activation energy of 3·1 eV. The transmittance window extends from this edge to 7μ with an absorption coefficient (α/cm) below 20; the transmittance of a polished plate 0·25 mm thick does not fall below 40% in the region 0·4 to 7μ. A.

535.345 : 537.563 : 551.510.535

8629. Photodissociation and photoionization of oxygen (O_2) as inferred from measured absorption coefficients. PO LEE. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 703–9 (*Sept.*, 1955).

Absorption coefficients, k, of O_2 between 1 320 and 200 Å were measured using a 2 m grazing incidence vacuum spectrograph. Three weak dissociation continua above 1 040 Å have been investigated. The "first continuum" between 1 320 and 1 270 Å had a maximum k-value of 13 cm^{-1} at 1 295 Å; another one between 1 220 and 1 096 Å was found to have a $k = 0{\cdot}23\ cm^{-1}$, and the third one between 1 096 and 1 040 Å had a value of about 3 cm^{-1}. The absorption near Lyman α and in various other "atmospheric windows" in adjacent regions is given. Between 1 040 and 740 Å strong absorption was observed due to diffuse bands, which were superimposed over the first ionization continuum with a maximum of 100 cm^{-1} at 920 Å. The main ionization continuum had a long wavelength limit at 683 Å and a flat maximum of 590 cm^{-1} at 510 Å. (In addition low absorption coefficients of less than 1 cm^{-1} have been found in N_2 between 1 040 and 910 Å.) As an application of these data, a survey calculation on ionospheric absorption was made which showed that the formation of the *E*-layer at 100 km may be due to the absorption of solar radiation by the first ionization continuum of O_2. It is also shown that solar radiation between 1 220 and 1 100 Å can reach the height of the *D*-layer by passing through the indicated atmospheric windows. A.

535.349 : 535.421 : 534.39

8630. Color control by ultrasonic wave gratings. A. H. ROSENTHAL. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 751–6 (*Sept.*, 1955).

Since ultrasonic waves in a transparent medium act upon light traversing the medium substantially parallel to the wave fronts in a way similar to a diffraction grating, it is possible to use such an ultrasonic wave grating as a colour modulator or as a monochromator at high modulation rates of the intensity and spectral position of the colour band transmitted. The relationships between position and resolution of the colour bands and the ultrasonic parameters are investigated, and spectrograms as well as spectrophotometric measurements are presented. Various aspects of ultrasonic colour modulation are considered. A.

535.361.2

8631. Influence of optical geometry and absorption coefficient on diffuse reflectance values. Å. S. STENIUS. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 727–32 (*Sept.*, 1955).

The two-constant theory of diffuse reflection and transmission deduced by Kubelka and Munk is much used for the determination of the absorption coefficient of dyed materials. Although the theory is derived for diffuse illumination of the specimen, it is often applied to reflectance values measured with reflectometers for parallel incidence. If the diffusing material can be prepared in the form of a thin sheet, a means is given to control the validity of the theory with respect to the optical geometry of the reflectometer. Experiments made with the geometries $R_{D,0}$, $R_{6.D}$, $R_{0,45}$ and $R_{60,D}$, show that if the material is coloured, only reflectance values obtained with diffuse incidence, as predicted by the theory, may be applied with great accuracy to the Kubelka–Munk theory. For white or light coloured materials, the optical geometry of the reflectometer is of minor importance in this respect. A.

535.371

8632. Luminescence of crystals at low temperatures. IX. *T* to *S* transitions of benzene. P. PESTEIL, A. ZMERLI AND L. PESTEIL. *C.R. Acad. Sci.* [*Paris*] **241**, *No.* 1, 29–31 (*July* 4, 1955) In French.

For Pt. VIII, see Abstr. 7858 (1955).

535.371

8633. Anomalous light emission of azulene. M. BEER AND H. C. LONGUET-HIGGINS. *J. chem. Phys.*, **23**, *No.* 8, 1390–1 (*Aug.*, 1955).

Azulene was found to fluoresce with a frequency corresponding to transition from the second excited singlet level to the ground state. No phosphorescence was observed. No emission corresponding to transition from the lowest excited singlet to the ground state was observed. These phenomena are discussed. A.

535.371

8634. Quenching of NaI fluorescence by H_2, HCl, CO_2, and H_2O. H. G. HANSON. *J. chem. Phys.*, **23**, *No.* 8, 1391–7 (*Aug.*, 1955).

The experimental quenching cross-sections of H_2, HCl, CO_2 and H_2O for the sodium *D* lines arising from the optical dissociation of the sodium iodide molecule have been determined by measurements with a photomultiplier tube. The velocities of the excited sodium atoms after dissociation of the sodium iodide molecules by ultraviolet light of different wavelengths have been determined by using an approximation for the repulsive potential curve of an excited sodium atom and normal iodine atom obtained from a measurement of the excitation of the sodium *D* lines as a function of exciting ultraviolet wavelength. The variation of quenching cross-section for HCl and CO_2 with relative velocities of

excited sodium atom and quenching molecules shows a decrease of cross-section with increase in relative velocity. The cross-section for H_2 shows little change with relative velocity in the range of velocities used. H_2O shows little quenching action. The source of ultraviolet light was a hydrogen discharge lamp and the wavelength of the exciting ultraviolet light in the 2 100–2 500 Å range was controlled by a reflection grating monochromator. A.

535.371

8635. Influence of alternating electric fields on the light emission of some phosphors. I. T. Steinberger, W. Low and E. Alexander. *Phys. Rev.*, **99**, *No.* 4, 1217–22 (*Aug.* 15, 1955).

The influence of an alternating electric field on the fluorescence and phosphorescence of various ZnS and ZnS : CdS phosphors was investigated. The light pulses and the average brightness of the luminescence were measured simultaneously. The wave pattern during fluorescence consists of two different pulses per cycle. The two pulses differ in their respective amplitudes, time dependence and shape. The pulses corresponding to positive polarity of the illuminated electrode show a similar behaviour for all phosphors. The second pulse differs for the various phosphors. Voltage dependence of the amplitudes and light sums per cycle were found to be different for the two pulses. These two pulses must be due to two different processes and suggest surface effects. A.

535.371 : 538.22

8636. Magnetism on optical excitation of manganese-activated zinc sulfide phosphors. K. Oshima and H. Nagano. *J. chem. Phys.*, **23**, *No.* 8, 1473–5 (*Aug.*, 1955).

Changes of magnetic susceptibility accompanying the optical excitation of manganese-activated zinc sulphide phosphors were measured. It was found that there was some change in susceptibility for phosphors containing manganese more than $9{\cdot}0 \times 10^{-4}$ g Mn/g ZnS. While there was concentration quenching for manganese emission intensity at high manganese concentration, the value of susceptibility change increased monotonically with concentration. From these results it is concluded that the non-radiative process in concentration quenching does not affect much the excitation probability and the lifetime of the excited state which is of the multiplicity giving rise to the susceptibility change. A.

535.371 : 548.7

8637. Current problems in crystalline luminescence. III. Transitions without light emission. IV. Cathodoluminescence. M. Curie and D. Curie. *Cahiers de Phys.*, *No.* 57–58, 52–80 (*May–June*, 1955) In French.

For Pt II, see Abstr. 6942 (1955). After a consideration of the correct formula for thermal activation of trapped electrons the various theories of non-radiative transitions in solids are discussed. These include those concerned with the temperature quenching of luminescence due to Peierls, Frenkel, Möglich and Rompe, Mott and Seitz, Klasens and Schön, Adirowitch and others. The discussion also includes the problem of concentration quenching. Pt IV deals with the theory and mechanism of cathodoluminescence. G. F. J. Garlick

535.375.54/.55

8638. Raman spectra of ortho and meta dichlorobenzene in different states and at different temperatures. D. C. Biswas. *Indian J. Sci.*, **29**, *No.* 4, 179–88 (*April*, 1955).

The Raman spectra of ortho and meta dichlorobenzene in different states and at different temperatures have been photographed and compared with each other and with that due to *p*-dichlorobenzene. In the case of the ortho compound two lines at 468 and 487 cm^{-1} due to the mode ε_g^+ coalesce to form one intense line at 478 cm^{-1} and the line at 433 cm^{-1} becomes weaker when the substance is solidified and cooled down to −180°C. These changes are explained by attributing the line at 487 cm^{-1} to a carbon ring vibration in a single molecule while the line at 468 cm^{-1} to the same vibration in a dimer. In the case of the meta compound some of the lines disappear with solidification and these results are also explained by assuming the presence of dimers as well as monomers in the liquid state and only dimers in the solid state of the substance. The Raman lines due to C—H valence oscillation become sharper with solidification so that the lines 3 062 and 3 080 cm^{-1} are resolved from each other. The new lines in the low-frequency region are different for the two substances. At a temperature of −60°C, the crystal of ortho dichlorobenzene produces a single new line at 25 cm^{-1}, while the crystal of *m*-dichlorobenzene produces two broad bands at 56 and 81 cm^{-1} respectively. When the temperature is lowered to −180°C, the line at 25 cm^{-1} of *o*-$C_6H_4Cl_2$ crystal disappears, but three new lines appear at 68, 81 and 92 cm^{-1} respectively. For similar change of temperature of the meta compound a new line appears at 35 cm^{-1}, the band at 56 cm^{-1} splits up into two lines at 50 and 61 cm^{-1} and the line 81 cm^{-1} shifts to 89 cm^{-1}. It is pointed out that although these two molecules have a smaller number of symmetry elements than the *p*-dichlorobenzene molecule, the number of the new lines in the low frequency region is much larger in the latter case. The significance of these results is discussed. A.

535.375.54

8639. Temperature dependence of the Raman spectrum intensity of a gypsum crystal. A. I. Stekhanov. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 4, 685–8 (1955) In Russian.

See also Abstr. 6516 (1954). Presents the results of an investigation of the distribution of the Raman spectrum of gypsum in the low-frequency range at +20 and −196°C. At the higher temperature, the intensities of lines 110, 122, 132 and 146 cm^{-1} decrease, while at −196°C they increase as the frequency increases. Besides this redistribution of intensity, the lowering of temperature to −196°C causes a very great increase of intensity of the lines 210 and 219 cm^{-1}. It has also been found that the intensities of the low-frequency lines of the Raman spectrum of gypsum vary with the orientation of the crystal. The maximum intensity of the spectrum as a whole is obtained when the incident beam is at right angles to the crystal axis *b*. Finally, it has been found that the distribution of intensity is different in spectra obtained by means of the two components of polarized diffuse light; this finding doubtless points to different

polarization states of the low-frequency Raman spectrum lines. A tentative explanation of the observed phenomena is given. F. LACHMAN

535.375.54

8640. Selection rules for Raman scattering: the case of calcite. O. THEIMER. Letter in *J. Phys. Radium*, **16**, *No.* 6, 493–4 (*June*, 1955) In French.

An explanation of the occurrence of forbidden lines is outlined, assuming the presence of non-localized electrons. G. F. LOTHIAN

535.375.55/.56

8641. Relative intensities of totally symmetrical vibrations in the Raman spectrum of gaseous neopentane. A. H. S. MATTERSON AND L. A. WOODWARD. *Proc. Roy. Soc. A*, **231**, 514–21 (*Sept.* 20, 1955).

Raman spectra are photographed for neopentane in the liquid state and in the gaseous state at approximately 1½ atm pressure. Only two of the three totally symmetrical vibrational modes appear. The ratio of their intensities is determined for the gas, and the result is used to test the validity of the Wolkenstein bond polarizability theory. It is concluded that Wolkenstein's assumption, that the polarizability of a bond is not affected by a change of bond orientation, is a quite good approximation for the particular modes considered. A.

535.376

8642. Cathodo-luminescence spectra of beryl. B. D. SAKSENA AND L. M. PANT. Letter in *J. sci. industr. Res.*, **14A**, *No.* 5, 246–7 (*May*, 1955).

Cathode-ray bombardment of beryl excites emission at 6400 Å; after prolonged exposure this emission is reduced, and new bands appear at 5700, 5300 and 4700 Å. J. FRANKS

535.376

8643. Field enhanced cathodo-luminescence in magnesium oxide. J. WOODS AND D. A. WRIGHT. Note in *Proc. Phys. Soc. B*, **68**, *Pt* 8, 566–9 (*Aug.*, 1955).

Cathodoluminescent layers of MgO show rapid increase in secondary electron emission and luminescence with increase of collector to layer potential. Removal of primary cathode-ray beam after producing the enhancement effect leaves the secondary emission and light output maintained for over an hour. Blue, green and red luminescence is observed under suitable layer conditions. G. F. J. GARLICK

535.376

8644. Electroluminescence excited by short field pulses. F. MATOSSI AND S. NUDELMAN. *Phys. Rev.*, **99**, *No.* 4, 1100–3 (*Aug.* 15, 1955).

The decay of the light emitted from several electroluminescent phosphors excited by periodically repeated voltage pulses of from 40 to 2500 μsec duration has been determined. The slopes of the decay curves after each individual pulse excitation become steeper as the pulse duration decreases. The heights of the luminescence peaks excited at the leading and trailing edges of the pulses also depend on the pulse time. The results are interpreted as confirming previous conclusions about the influence of polarization charges. Numerical evaluation yields the correct order of magnitude for the "critical time" needed for the accumulation of polarization charges. A.

535.376

8645. Scintillation response of anthracene to low-energy protons and helium ions. E. J. ZIMMERMAN. *Phys. Rev.*, **99**, *No.* 4, 1199–203 (*Aug.* 15, 1955).

Photomultiplier pulse amplitudes produced by light from anthracene crystals bombarded by protons and helium ions from 25 to 375 keV were measured. Both response curves (pulse height *v.* energy) are non-linear, but that for protons bends away from the energy axis while that for helium ions bends towards it. Both curves extrapolate smoothly to the origin, indicating an absence of any non-scintillating surface layer more than about 10 keV thick. Present knowledge of stopping cross-sections (dE/dx) for anthracene is inadequate to permit an unambiguous determination of the specific fluorescence (dL/dx) from the observed pulse amplitudes. However, some qualitative conclusions can be drawn concerning Birks's theory of the fluorescent process. A.

535.377 : 537.583

8646. Thermoemission and thermoluminescence in fluorspar. A. BOHUN. *Czech. J. Phys.*, **5**, *No.* 2, 224–38 (*April*, 1955) In German.

Fluorite crystals coloured by X-rays show thermoluminescence when warmed. This is accompanied by electron emission from the surface and quantitative correlation is shown between electron emission density curve and the thermal glow curve. The electron emission process provides a method of investigating colour-centre energy levels in the crystals. G. F. J. GARLICK

535.39

8647. Optical constants of metals in the infra-red—conductivity of silver, copper and nickel. J. R. BEATTIE AND G. K. T. CONN. *Phil. Mag.*, **46**, 989–1001 (*Sept.*, 1955).

The experimental methods used to measure the optical constants of metals at infrared frequencies have already been described [Abstr. 2628–9 (1955)]. The conductivity of evaporated aluminium, silver, copper and nickel is reported. Since the penetration depth is small the behaviour is closely related to the nature of the surface of the metal; attention is therefore paid to the preparation of various representative surfaces including hand polished, electrolytically polished and those obtained by evaporating *in vacuo*. By giving care to the manner of presenting experimental results, the various factors which contribute to the absorption may be discriminated. Figures are given of relaxation times, conductivity and the effective number of free electrons per atom. Elementary interpretations are given. A.

535.39

8648. Resonance absorption of nickel in the infra-red region. J. R. BEATTIE AND G. K. T. CONN. *Phil. Mag.*, **46**, 1002–6 (*Sept.*, 1955).

Means are described whereby the absorption in the infrared of "free" or "conduction" electrons may be abstracted from the total which is measured experimentally. When this is done, it is clear that there is residual absorption in nickel which may be caused by electron transitions from the *d*- to the *s*-band. The mechanism is being further explored. A.

535.39

8649. Some new formulas for determining the optical constants from measurements on reflected light. R. W. Ditchburn. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 743–8 (*Sept.*, 1955).

The theory of reflection at the surfaces of metals and semiconductors (with special reference to the latter) is considered. Convenient equations for calculating the real and imaginary parts of π^2 (π is the complex index) from measurements of Δ (the phase difference) and ψ ($\tan\psi = a^2$ = the ratio of the two reflection coefficients) for one angle of incidence are derived. A second set of equations for calculating the optical constants when either ψ or Δ have been measured at two angles of incidence are given. The errors are analysed to show which method is most sensitive when the constants are in certain ranges. Difficulties caused by inhomogeneity near the surface and by surface films are discussed, and possible methods of elimination are suggested. A.

535.39 : 539.234

8650. The infra-red properties of some metallic films. J. N. Hodgson. *Proc. Phys. Soc. B*, **68**, *Pt* 9, 593–602 (*Sept.*, 1955).

The values of the refractive index n and the extinction coefficient k have been measured for evaporated films of gold, silver, copper, zinc, tin and aluminium, at wavelengths between 1 and 15 μ, by a reflection method. The apparatus for the measurements contained two selenium film polarizers, and an infrared spectrometer with two rock salt prisms and a radiation thermocouple. Theoretical formulae for the infrared properties of a metal are discussed and it is shown that the present experimental results are not sufficiently accurate to distinguish between the classical free electron theory and later modifications. The experimental results have been compared with theory by a graphical method. Some inferences about electronic band structures are made from the comparison of experimental points with theoretical curves. A.

535.416 : 537.525.8

Glow discharge resonance. *See Abstr.* 8802

535.417

8651. Interferometer for phase and amplitude measurements. H. Wolter. *Z. Phys.*, **140**, *No.* 6, 565–76 (1955) In German.

A stable interferometer is formed with one plate of a Jamin interferometer by using a mirror image of this plate to replace the second plate. It is automatically adjustable for low orders and permits phase measurements over even 360°. High sensitivity (mean error of phase $\lambda/400$) is achieved by using polarized light and employing ellipticity analysis. Polarization in the separated beams is best secured with plates of mica. The technique described attains the sensitivity of phase-contrast methods and is not subject to diffraction anomalies. S. TOLANSKY

535.417

8652. Wavelength independent equalization of amplitudes for the three-slit interferometer. D. Paris. *Z. Phys.*, **141**, *No.* 4, 507–14 (1955) In German.

It is shown that with the half-wave thin film of mica used formerly for the equalization of amplitude in the three-slit interferometer, the system can be made virtually independent of wavelength. Thus the same mica sheet can be used for more wavelengths than that for which its thickness is half-wavelength. The result is only a small reduction in sensitivity over the increased wavelength range. S. TOLANSKY

535.417

8653. Fabry–Perot interferometer mirrors with dielectric multilayers. S. Penselin and A. Steudel. *Z. Phys.*, **142**, *No.* 1, 21–41 (1955) In German.

A description is given of the production of multilayer mirrors for Fabry–Perot interferometers using vacuum evaporation. The mirrors are quarter wavelength thick and consist alternatively of the following materials. For 3000 to 4000 Å materials are $PbCl_2$ and MgF_2. For wavelengths greater than 4000 Å zinc sulphide and cryolite are employed. When freshly prepared films are used reflecting coefficients exceeding 97% are secured with a mean absorption of 0·9% for the zinc sulphide and cryolite combination. Absorption of 1·9% obtains for the lead chloride and the magnesium fluoride combination. Reflectivities are such that the fringe width is determined primarily by errors in the optical flats and not by reflectivity characteristics. Lead chloride layers are protected against the activity of dampness with a half-wavelength layer of magnesium fluoride. In the ultraviolet interferometric effects obtained with the multilayers are much superior to those of aluminium mirrors. S. TOLANSKY

535.417

8654. Photoelectric recording of reflecting echelon fringes. T. A. Littlefield. *Brit. J. appl. Phys.*, **6**, *No.* 9, 333–5 (*Sept.*, 1955).

The apparatus described consists of a reflecting echelon interferometer used in conjunction with a photomultiplier to measure the relative intensities of hyperfine structure components of spectral lines. The arrangement eliminates the troublesome "envelope effect" which leads to distortion and displacement. The choice of exit slit width is discussed and the dispersion of wave-number along the pen recorder trace is shown to be almost linear. Tests with the cadmium triplet $2^3S_1 - 2^3P_{0,1,2}$ indicate that the method is reliable when the components are completely resolved. A.

535.417 : 531.715.1

8655. The effects of collimation and oblique incidence in length interferometers. I. C. F. Bruce. *Austral. J. Phys.*, **8**, *No.* 2, 224–40 (*June*, 1955).

An investigation has been made of the effects of position and size of diaphragm apertures on the interference fringes in length interferometry. The results indicate that, while the well-known correction formula for the effect of the oblique rays from a point source off the optic axis is always applicable, the effect of finite area of aperture is a more complex one and is not in general proportional to the length measured. This effect depends essentially on the phase differences arising from different points of the aperture and is oscillatory in character. For a narrow slit the maximum fringe displacement arising from this effect is not greater than about 0·15 fringe.

For a circular aperture the maximum effect is about 0·5 fringe and for a square aperture about 0·35 fringe. A.

535.417 : 531.715.1

8656. The effects of collimation and oblique incidence in length interferometers. II. B. S. THORNTON. *Austral. J. Phys.*, **8**, *No.* 2, 241–7 (*June*, 1955).

It is important in length determinations by interferometry to know the effect on the fringe pattern of an entrance aperture of finite size through which the light enters the interferometer. The correction generally applied has been found to be in error (Bruce, 1955). This paper is a further discussion of this correction. Both two-beam and multiple-beam systems are discussed and show, in accordance with experiment, that the correction at present applied for the finite size of the aperture appears to be invalid. Formulae are developed and curves are given from which the correction to be applied for any particular length and aperture size can be very easily determined. A.

535.417 : 539.155.2

8657. Interferometer for analyzing mixtures of hydrogen isotopes. S. SCHNEIDER. Note in *Rev. sci. Instrum.*, **26**, *No.* 6, 623–4 (*June*, 1953).

For identification of deuterium present in hydrogen, a Fabry–Perot interferometer, of suitable thickness, can isolate H_α and D_α when a filter is used, and thus concentrations can be determined. A simple fixed interferometer for the purpose is described. It consists of a doubly-silvered selected piece of muscovite mica of thickness $10{\cdot}5 \times 10^{-3}$ in. Concentrations as low as $\frac{1}{4}\%$ of D can be recognized in the interferometer fringes. S. TOLANSKY

535.421

8658. Calculations of grating efficiency in the soft X-ray region. G. SPRAGUE, D. H. TOMBOULIAN AND D. E. BEDO. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 756–61 (*Sept.*, 1955).

Modified expressions for reflection coefficients are derived for the purpose of predicting the energy distribution among spectral orders produced by a grating at near grazing incidence. Predictions carried out under reasonable simplifying assumptions are compared with experimental data obtained by the use of a grating with 30 000 lines/in. set at a grazing angle of 4·64°. Experimental evidence indicates that in the particular arrangement first-order spectra begin to have appreciable intensity at about 60 Å, while second and third orders become observable at 100 and 150 Å, respectively. At 110 Å, the fraction of the incident energy present in the first- and second-order spectra is 5·4 and 1·5%, respectively. The calculations are in good general agreement with the observed response of the grating. A.

535.421

8659. Quantitative method for measuring the resolution of a large grating. D. H. RANK, J. N. SHEARER AND J. M. BENNETT. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 762–6 (*Sept.*, 1955).

A method capable of giving quantitative information about the resolving power of large high-quality diffraction gratings has been developed. This method is based on the ability of the grating to resolve the perpendicular components of a normal Zeeman triplet when the central parallel component is removed. Since the splitting of these components is a known function of the field strength, one has in effect two lines whose separation can be varied at will, thus providing as stringent a test for the grating as is necessary. Suitable corrections are made for the effect of Doppler breadth in the source and for the finite width of the slit. The resolving power of a plane grating has been measured by this method under various conditions and is shown to be a constant fraction of the theoretical value. The effects of error of run on resolution and focus have been reviewed and investigated experimentally. Non-planeness of the grating blank has been measured in order that the contribution of this defect to the focal curve can be calculated and separated from the shift of focus caused by linear error of run. A.

535.43 : 548.7

8660. Observation of the Rayleigh scattering of single crystals of sodium chloride. L. TAUREL AND J. CHAPELLE. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 26, 2507–8 (*June* 27, 1955) In French.

The dependence of scattering on sample as found in Abstr. 7613 (1953) is due to dislocation structures. The scattering of a synthetic and a natural perfect crystal are compared. The results for the synthetic one agree with theoretical values, those for the natural one are much larger. The intensity variation is proportional to the absolute temperature for the natural crystal but too small to measure for the synthetic one. The Rayleigh factor for benzene is found to be $31{\cdot}3 \pm 3{\cdot}7$, in good agreement with the value found for quartz [Abstr. 7877 (1955)]. C. TURNER

535.434

8661. Scattering of light by colloidal particles and the determination of their sizes. Y. G. NAIK AND D. K. SOHONI. *Indian J. Phys.*, **29**, *No.* 2, 55–64 (*Feb.*, 1955).

Two optical methods based on the Mie theory of the scattering of light by spherical particles are used in the present investigation for determining the size of the colloidal particles. One method is based on the comparison of the experimentally observed distribution of the intensity of light scattered by colloidal particles in different directions with the theoretical distribution of the same by particles of different sizes. The other method is based on the comparison of the dissymmetry of scattered light with the theoretical dissymmetry for similar particles. Both the methods are used for determining the sizes of the colloidal particles of Fe_2O_3 and As_2S_3 sols and it is found that the two methods give results which are in close agreement with each other. A.

535.514.2

8662. Study of the reflection factor of thin cryolite films near the Brewster incidence angle at the air-film surface. P. BOUSQUET. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 26, 2502–4 (*June* 27, 1955) In French.

Experimental results are presented which do not confirm the theoretical values based upon Fresnel's equations. It is concluded that the film surface does not act as a simple surface of separation and that the use of Brewster incidence as a means of deducing the refractive index of the film is not justified. R. W. FISH

535.514.2 : 541.183.022

8663. Optical study of monomolecular layers of haemin. P. Dubouloz and R. Rinaldi. *Rev. Opt.*, **33**, *No.* 12, 630–41 (*Dec.*, 1954) In French.

Haemin on the surface of water gives monomolecular layers having interesting optical properties, in relation to the high value of its absorption coefficient for some wavelengths. In particular the Brewster angle varies with those layers, the displacement being perfectly reproducible and having values up to 35′ for $\lambda = 3650$ Å. They can be laid on silica or glass. They can be stratified, and so the displacement of the Brewsterian angle or the absorption spectrum may be studied, On solid supports layers seem to be of different types, probably according to the position of molecules. A.

535.514.2 : 541.183.022

8664. Relation between absorption coefficient and variation of the Brewster angle for thin films formed by an absorbing material. R. Rinaldi and P. Dubouloz. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 17, 1697–700 (*April* 25, 1955) In French.

Continuing previous work (see preceding abstract) it is found that for mono- or multi-molecular films of haemin the Brewster angle–λ curve follows to a first approximation the absorption coefficient–λ curve. This may develop into a method for measuring absorption curves for thin films. G. F. Lothian

535.515 : 536.424

8665. Optical observation of a phase change of manganese fluosilicate hexahydrate. I. Tsujikawa and L. Couture. Letter in *J. Phys. Radium*, **16**, *No.* 5, 430–1 (*May*, 1955) In French.

The type of birefringence changes between about −40°c and −50°c so as to be consistent with rhombohedral symmetry above −40°c and with a symmetry lower than rhombohedral below −50°c.

A. R. Stokes

535.55

8666. Oscillograph recording of changes of double refraction. K. Stecker. *Ann. Phys.* [*Leipzig*] **16**, *No.* 3–4, 111–19 (1955) In German.

A method is given which gives a simple means of recording rapid changes in double-refraction, δ, produced in any object. Linearly polarized light passes in turn through the object, a quarter-wave ($\lambda/4$) plate, an analysing prism into a photocell connected to a cathode-ray oscillograph. The object and $\lambda/4$ plate are set with their fast vibration directions at 45° to that of the incident light. From a measure of the intensity, as recorded by the cathode-ray oscillograph, first with the $\lambda/4$ plate absent and then present a value for δ can be found. The theory of the method and the range of application is presented and errors discussed. Experimental hints are given.

H. G. Jerrard

535.55

8667. A polarized light study of glass fibre laminates. G. A. Horridge. *Brit. J. appl. Phys.*, **6**, *No.* 9, 314–19 (*Sept.*, 1955).

The use of a stress sensitive resin (Marco 28C) in the formation of a glass-fibre-resin laminate makes possible a photoelastic stress analysis of a highly anisotropic material. This will have an application in conjunction with theoretical stress analysis in anisotropic materials; it is hoped that it will also be of value to the designer of reinforced plastic structures. The relation between the resin and the fibres in a laminate under load has been studied with the aid of a polarizing microscope. A disconcerting feature is the discovery of a pattern of cracks which open under relatively small stress, and which may provide a pathway for erosion by water. A.

535.55 : 548.7

Photoelastic observations of the expansion of alkali halides on irradiation. *See Abstr.* 9246

535.551

8668. A new model material for photoelasticity. C. L. Amba Rao. Letter in *Nature* [*London*] **176**, 81 (*July* 9, 1955).

It is stated that agar is suitable. The fringe constant is 0·08 lb.in.$^{-2}$ fringe^{-1} for a thickness of 1 in. for 2 to 3% concentration at 29°c compared with 0·14 lb. in.$^{-2}$ fringe^{-1} for 15% gelatin. Young's modulus is 14 lb.in.$^{-2}$ for a 5% agar solution compared with 6 lb.in.$^{-2}$ for 13% gelatin. H. G. Jerrard

535.557 : 539.216.1

8669. Solution of an integral equation arising in optical studies of oriented filaments. E. F. Gurnee. Letter in *J. appl. Phys.*, **26**, *No.* 7, 918 (*July*, 1955).

The equation giving the radial distribution of birefringence for monofilaments and fine fibres which was found by Gurnee [Abstr. 3159 (1955)] is solved.

H. G. Jerrard

535.56

8670. A new method of determining optical rotation. I. Šolc. Letter in *Czech. J. Phys.*, **5**, *No.* 2, 272–3 (*April*, 1955) In Russian.

A new type of prism is described which is placed on the simplest conventional type of polarimeter, with a wafer of quartz, in the position normally occupied by the tube of solution. Visual inspection tells immediately whether the wafer is *d*- or *l*-quartz. Two equal right-angle triangular blocks of quartz are ground up. One is of *l*- and the other of *d*-quartz. The optical axes are parallel to the long sides enclosing the right angles. Let α be the angle opposite the side. If α is greater than 40° the two blocks are cemented together by Canada balsam on their hypotenuse faces forming a parallelepiped. The polarimeter is adjusted for || light, then illuminated with white light. Down axial plane of the block the *d*- and *l*-rotations compensate; on opposite sides of the plane the block exhibits a resultant *d*- or *l*-rotation. Turning the polarizer gives vertical dark bands in the centre of the field, trailing off into coloured fringes on the outside. Putting in a slip of *d*-quartz clearly causes the black fringes to move sideways towards the angle α of the *d*-rot. component of the parallelepiped. The displacement X of the dark fringes in terms of wafer thickness L is given by $X = 0{\cdot}5L \cot \alpha$.

C. R. S. Manders

535.563 : 538.613

8671. A new demonstration model for the optical Faraday effect. M. Kornetzki. *Siemens-Z.*, **29**, *No.* 7, 268–71 (*June*, 1955) In German.

A modern version of an apparatus due to Rayleigh is described. This shows the non-reversibility of light when the plane of polarization is rotated by Faraday

effect between crossed polarizers. Practical details are given. R. W. FISH

535.563 : 538.614

8672. Magnetic rotation of nitric oxide under low pressure. R. DE MALLEMANN AND J. GRANGE. *C.R. Acad. Sci.* [*Paris*] **241,** *No.* 1, 5–7 (*July* 4, 1955) In French.

Measurements are made for pressures between 2 500 and 200 mm mercury and temperatures between 6 and 85°. The variation of the purely paramagnetic rotation with temperature agrees with van Vleck's theory. The molecular rotation of the gas at 16° is $-462\,\mu r$. The specific rotation is independent of pressure up to 2·5 atm. C. TURNER

535.65

8673. Use of charts for rapid calculation of color difference. H. R. DAVIDSON AND J. J. HANLON. *J. Opt. Soc. Amer.*, **45,** *No.* 8, 617–20 (*Aug.*, 1955).

Colour difference calculations based on the MacAdam visual sensitivity ellipses have been found by several workers to correlate with visual observations as well as or better than do calculations based on other data. In the past, however, these calculations have been rather cumbersome so that their application has been restricted. This paper describes a series of charts, derived from the MacAdam ellipses, which may be used to greatly simplify and speed the calculations. A.

535.65 : 518.5

8674. Computation of trichromatic coordinates using the IBM 604 electronic calculating punch. A. J. DERR. Letter in *J. Opt. Soc. Amer.*, **45,** *No.* 9, 772–3 (*Sept.*, 1955).

Gives a suggested programme for the machine computation of trichromatic co-ordinates from values of transmission or reflection factors at the usual set of selected wavelength ordinates. J. W. T. WALSH

535.7

Physiological optics. Vision. *See under* "Medical science. Human physiology." Decimal classification 612.84

535.8 : 771.35

8675. Performance testing of photographic lenses. F. G. BACK. Letter in *J. Opt. Soc. Amer.*, **45,** *No.* 9, 768 (*Sept.*, 1955).

The author discusses criticism [Abstr. 235 (1955)] of a previous paper. He maintains that both resolving power and image contrast are necessary to specify lens performance. A system of matrices are suggested as a description of the lens performance over the whole field. R. W. FISH

535.8 : 771.35

8676. Note on a suggested method for evaluating image sharpness. N. J. RUMSEY. Letter in *J. Opt. Soc. Amer.*, **45,** *No.* 9, 768–9 (*Sept.*, 1955).

The method suggested by Back [Abstr. 8157 (1953)] is said to be unsatisfactory in concept although it may yield reasonably satisfactory results when applied to some photographic lenses. R. W. FISH

535.8 : 771.35

8677. Answer to N. J. Rumsey's "Note on a suggested method for evaluating image sharpness." F. G. BACK. Letter in *J. Opt. Soc. Amer.*, **45,** *No.* 9, 769 (*Sept.*, 1955).

The criticisms made by Rumsey (preceding abstract) are discussed. The evaluation of lens performance from the distance between the planes of maximum resolving power and of maximum contrast is said to be of general application, except for visual instruments where the accommodation of the eye is of importance. R. W. FISH

535.81

8678. Some properties of light guides. G. M. ETTINGER. *Rev sci. Instrum.*, **26,** *No.* 8, 763–4 (*Aug.*, 1955).

In some scintillation counter applications it is impracticable to place the photomultiplier tube in close proximity to the scintillation crystal; light guides are therefore employed. These guides produce considerable attenuation, so that photomultiplier signal-to-noise ratio becomes low. Factors affecting attenuation in light guides are mentioned in this paper; in particular, the effects of various preparations of the guide surface are considered. A.

535.81

8679. The effect of eccentric loading of optical flats during grinding or polishing. N. J. RUMSEY. *J. sci. Instrum.*, **32,** *No.* 9, 338–9 (*Sept.*, 1955).

During grinding or polishing, optical flats of glass or quartz are often eccentrically loaded to modify the angle between the front and back surfaces. It is shown that if too great a loading is applied too close to the edge of the flat a kink is formed, namely, a part of the original surface remains unworked and will lie at an angle to the freshly worked part. A.

535.81 : 666 : 534.26

Ultrasonic diffraction patterns in some optical glasses. *See Abstr.* 8570

535.822.17

8680. Measurement of absolute phase by phase contrast. R. FLEISCHMANN AND H. WEGENER. *Z. Phys.*, **141,** *No.* 4, 500–6 (1955) In German.

The phase contrast image of an edge can be used to determine the phase difference introduced by the object forming the edge. The theory has been confirmed by measurements made on an evaporated iron film, which indicate that accuracies of $\pm 0{\cdot}4°$ may be obtained. R. W. FISH

535.824.2 : 535.34.07

8681. Reflecting objective for microspectroscopy. W. THORNBURG. *J. Opt. Soc. Amer.*, **45,** *No.* 9, 740–3 (*Sept.*, 1955).

Interest in the low-temperature ultraviolet absorption spectra of biological materials has led to the design and construction of a reflecting microscope objective in which the conventional, two-element system is modified by the addition of a reflecting correction plate. The system has high aperture, low central obstruction, long working distance and zero chromatic aberration. The correction plate simplifies certain problems in construction and eliminates the need for figuring surfaces with deep curvatures. A.

535.832

8682. Instrument for measuring the marginal power of spectacle lenses. F. E. WASHER. *J. Opt. Soc. Amer.*, **45,** *No.* 9, 719–26 (*Sept.*, 1955).

An instrument is described that permits the measurement of meridional power at selected intervals from the centre of the lens to the edge of the useful field.

The viewing system simulates the rolling eye so that measurements are made under conditions closely approximating conditions of use. The instrument is capable of measuring spherical and cylindrical power with respect to the vertex sphere. A divided circle permits the measurement of distortion. Results of measurement are presented for two types of spectacle lenses of identical powers. A.

HEAT 536

536.2.01 : 537.311.33

8683. On the work of G. M. Avak'yants on the theory of the equation of transfer in a strong electric field. I. M. Tsidil'kovskiĭ and F. G. Bass. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 2, 245 (1955) In Russian.

Criticizes Avak'yants's paper [Abstr. 887–8 (1955)] both on theoretical and experimental grounds and concludes that this work makes no contribution to the problems of the behaviour of semiconductors in strong electric fields. W. BARDSLEY

536.21

8684. Thermal conductivity of germanium at ambient temperatures. K. A. McCarthy and S. S. Ballard. *Phys. Rev.*, **99**, *No.* 4, 1104 (*Aug.* 15, 1955).

The thermal conductivity of high-purity germanium has been measured; it varies approximately linearly from 0·61 watt (cm.deg.c)$^{-1}$ at 5°c to 0·50 watt (cm.deg.c)$^{-1}$ at 95°c. A.

536.212.3 : 536.631

8685. Thermal constants of pyrophyllite and their change on heating. A. E. Carte. *Brit. J. appl. Phys.*, **6**, *No.* 9, 326–8 (*Sept.*, 1955).

Results are given for the thermal conductivity, thermal diffusivity and specific heat of pyrophyllite before and after heating to temperatures up to 1 200°c. Before heating, the conductivity in directions parallel to the bedding planes is about 0·01 cal.cm/cm^2 sec.deg.c (0·04 joule cm/cm^2 sec.deg.c) and at right angles to these planes it is half this value. The difference is attributed to the effects of bedding and to preferred orientation of the crystals. A method of finding the directions of maximum and minimum conduction is outlined. As the heating temperature is increased the two conductivities converge, until after heating to 1 200°c the physical and chemical changes are such as to make the material thermally isotropic with a conductivity of about 0·003 cal. cm/cm^2. sec. deg. c (0·01 joule cm/cm^2. sec. deg.c). Some other properties and uses of pyrophyllite are mentioned. A.

536.24

8686. Investigation of the effect of the rate of motion of the water current on the heat exchange coefficient on boiling in an inclined tube. F. F. Bogdanov. *Izv. Akad. Nauk SSSR, Otdel. tekh. Nauk*, *No.* 4, 136–40 (1955) In Russian.

The results of an investigation on the effect of the rate of motion of the liquid on the heat exchange coefficient, when it boils in an inclined tube, are described. Figures are given to show the heat exchange coefficient as a function of the circulation rate, for various values of the pressure and specific thermal load. It is shown that this coefficient is a linear function of the circulation rate, in the range of this parameter investigated. Some considerations are given regarding the mechanism of the heat exchange process when the circulating liquid boils in tubes, and a criterial form of generalization is proposed for this form of heat exchange. J. B. SYKES

536.24

8687. Heat transfer experiments with sodium and sodium potassium alloy. W. B. Hall and A. E. Jenkins. *J. nuclear Energy*, **1**, *No.* 4, 244–63 (*June*, 1955).

The theoretical approach to the problem of heat transfer in liquid metals is briefly reviewed. The difference between this approach and that used in the case of fluids with a high Prandtl number is due to the fact that the thermal conductivity of a liquid metal may be so high as to swamp the "eddy conductivity" in a turbulent stream. A description is given of experiments in which the heat-transfer coefficients between two annuli, each carrying a flow of liquid metal, were measured. Whilst a direct comparison with results obtained with a circular tube is not possible, the results are in quite good agreement with theoretical values given by Lyon (1951). In the course of the work it was found that there were significant variations in temperature around the annuli carrying the liquid metal in the heat exchanger. It is thought that these variations were due to slight eccentricity of the exchanger tubes. An approximate theoretical treatment indicates that such variations are likely to be greater (when expressed as a fraction of the overall temperature difference) in the case of liquid metals than in the case of fluids with a higher Prandtl number. In these experiments, where the heat flux was about 50 watts per cm^3, the temperature variations were quite small, but if full advantage is taken of the liquid metal to obtain high heat fluxes, they might be so large as to produce serious thermal stresses and distortion of the heat exchanger. A.

536.24

8688. Energy exchange between cold gas molecules and a hot graphite surface. R. Gomer and L. Meyer. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1370 (*July*, 1955).

Experiments are described in which the transport of heat from a graphite filament by dilute gases is measured. The rate of heat transport per gas molecule is found to be independent of the temperature of the filament (850–1 500°c) but to depend on the nature and density of the conducting gas. It is claimed that results are in contradiction with established theories. In the published results the rate of transport of heat by radiation is not stated. R. EISENSCHITZ

536.25

8689. Experiments on over-stable thermal convection in mercury. D. Fultz and Y. Nakagawa. *Proc. Roy. Soc. A*, **231**, 211–25 (*Aug.* 22, 1955).

Experiments on the onset of thermal instability in rotating layers of mercury are described. In agreement with the theoretical work of Chandrasekhar (see abstract following) the experiments show that the instability sets in as oscillations of increasing ampli-

tude. Both the temperature gradients at which the instability sets in and periods of the oscillations in the marginal state are in agreement with the theoretical predictions. A.

536.25 : 551.513 : 523.877

8690. The instability of a layer of fluid heated below and subject to Coriolis forces. II. S. CHANDRASEKHAR AND D. D. ELBERT. *Proc. Roy. Soc. A*, **231**, 198–210 (*Aug.* 22, 1955).

The theory described in Pt I [Abstr. 4762 (1953)] is extended in a manner which enables the determination of the critical Rayleigh number for the onset of thermal instability of a layer of fluid heated below and subject to rotation via a marginal state of purely oscillatory motions. Numerical results are derived for the case when the ratio of the kinematic viscosity to the thermometric conductivity has a value (=0·025) equal to that for mercury at ordinary temperatures. For a comparison of the theoretical results obtained in this paper with those of experiments see preceding abstract. A.

536.33.08

8691. The effect of tempering on the resistance of evaporated bismuth bolometers. H. REIMANN. *Ann. Phys.* [*Leipzig*] **16**, *No.* 1–2, 52–8 (1955) In German.

The construction of the bolometer is first described with particular reference to the relation between the thickness of the bismuth layer and the bolometer resistance. The temperature coefficient was measured by immersing the bolometer in an oil bath and the results are shown graphically. Tempering was done in an electric oven immediately after the construction of the instrument, and it was found that the natural ageing time of the bolometer could be considerably shortened. E. H. DOCK

536.33.08

8692. Experiments with the bismuth bolometer and radiation modulated to have a rectangular or sine wave form. H. REIMANN. *Ann. Phys.* [*Leipzig*] **16**, *No.* 1–2, 59–67 (1955) In German.

The bolometer under test is connected to a bridge circuit supplied by a low-frequency generator. The out-of-balance output is fed to an amplifier and the final effect is shown on a cathode-ray oscilloscope. The rectangular modulation was obtained using a suitably cutout revolving disk; sine modulation of the light was obtained by using similar but differently cut-out sectors, a revolving blade (after Kofink) or a rotating nicol prism. Comparisons of performance were made by calculating the ratios of the amplitudes photographed from the oscilloscope, and plotting against frequency. Results are given graphically and typical oscilloscope traces are included. Values obtained for $\tau \cdot \nu_{\frac{1}{2}}$ were 5–9% below the theoretical values (τ is the time constant and $\nu_{\frac{1}{2}}$ the half-value frequency according to Czerny *et al.* and G. C. Mönch *et al.*). E. H. DOCK

536.4.031

8693. Maximum superheating of water as a measure of negative pressure. L. J. BRIGGS. *J. appl. Phys.*, **26**, *No.* 8, 1001–4 (*Aug.*, 1955).

Water superheated to the limit in an open tube develops an internal negative pressure P_n (tending to tear the molecules apart) equal to the saturation vapour at that temperature, less one atmosphere. Kendrick, Gilbert and Wisner heated water in an open thin-walled capillary *U*-tube to 270°C for 5 sec before it exploded ($P_n = 53$ atmos). Using their method, the writer heated three tubes to 264, 266 and 267°C for 5 sec or more before explosion occurred ($P_n = 48$ to 51 atmos). The cohesive strength of water is thus sufficient to withstand an internal negative pressure of over 51 atmos at 267°C. At this temperature an additional negative pressure (applied externally through centrifugal force) would rupture the water column. It has been predicted from van der Waals's equation that the external negative pressure which the system could withstand would vanish at 273°C, in fair agreement with experiment. A.

536.422

8694. Rate of evaporation of graphite. R. J. THORN AND G. H. WINSLOW. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1369 (*July*, 1955).

This has been determined by measuring the rate of deposition by observing the change with time of the apparent temperature of the source measured through the deposit. Although the source temperature was determined by three different methods, the real temperature may be uncertain; the experiment does not show a ratio of 10^3 in the rates of evaporation obtained from effusion out of a Knudsen cell and from a graphite surface. The experiments indicate a somewhat lower rate of sublimation from the surface than from the cell. E. W. KELLERMANN

536.422.1

8695. Evaporation of submicroscopic ice crystals. M. F. GOURLEY AND W. D. CROZIER. *J. chem. Phys.*, **23**, *No.* 7, 1298–301 (*July*, 1955).

Experiments, designed to interpret certain meteorological observations, provide evidence that very small ice crystals may have evaporation rates much lower than predicted on the basis of the vapour pressure of macroscopic ice. Small ice crystals, formed by spontaneous sublimation in nuclei-free air, were suspended in a strongly desiccating atmosphere for a time far longer than should have been sufficient for their complete evaporation. Though they decreased in size below the minimum observable optically, their presence was demonstrated by their ability to nucleate visible ice particles when exposed to a supersaturated atmosphere. In representative experiments, ice-forming nuclei were observed in a 250 cm³ chamber three hours after the admission of nucleus-free ice particles of about 1 μ radius, the chamber containing an atmosphere at −20°C with water vapour pressure at about 50% of saturation with respect to macroscopic ice. There was some evidence, however, that the ice-forming residues diminish in effectiveness at a low time rate. A.

536.423.1 : 536.53

8696. An electric method of recording the stratification of the steam-water mixture. A. K. KATARZHIS, S. I. KOSTERIN AND B. I. SHEININ. *Izv. Akad. Nauk SSSR, Otdel. tekh. Nauk*, *No.* 2, 132–6 (1955) In Russian.

Details are given concerning a proposed method of using an electrically heated filament to record this stratification by virtue of the change in temperature

and resistance when it passes from one medium to the other. The effect of the water film remaining on the filament when it enters the steam is taken into account. A nomogram is given to calculate this effect. The results of several experiments are exhibited in a table. It is shown that the proposed method gives satisfactory results. J. B. SYKES

536.424

8697. On the graphite–diamond equilibrium. R. BERMAN AND F. SIMON. *Z. Elektrochem.*, **59**, *No.* 5, 335–40 (1955).

The equilibrium curve between graphite and diamond is calculated up to 1 200°K by making use of some new experimental data. The justification for extrapolating the values to higher temperatures is given. The equilibrium pressures below 1 200° are shown in a table, while above 1 200°K the curve can be represented by the equation $P_{ats} = 7000 + 27T(°K)$, which should be accurate to within about 5%. A.

536.424 : 536.48

8698. On the kinetics of the isothermal martensite transformation close to absolute zero. B. YA. LYUBOV AND YU. A. OSIP'YAN. *Dokl. Akad. Nauk SSSR*, **101**, *No.* 5, 853–6 (1955) In Russian.

Kulin and Cohen [*Journal of Metals*, **188**, *No.* 9, 1139 (1950)] have shown that the martensite transformation occurs fairly rapidly in various alloys at temperatures down to 4°K, and this was held to disprove the theory that this transformation is an ordinary phase transformation, in favour of the rival theory that it is a mechanical displacement of the atomic planes. The present paper shows, however, that the classical analysis used is inadequate at such low temperatures; a quantum treatment, taking account of the narrowness of the energy barriers, shows that the results obtained are not decisively in favour of either theory. J. B. SYKES

536.44

8699. Critical constants of *n*-butanol. R. SINGH AND L. W. SHEMILT. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1370–1 (*July*, 1955).

p-v-T data for *n*-butanol have been determined. Equations are given showing the densities of the saturated vapour and liquid as function of the temperature. The critical density is found by an application of the law of rectilinear diameters and found to be $0{\cdot}2700\,g.cm^{-3}$. $T_c = 286{\cdot}95°C$ and $p_c = 48.60$ atmos. W. GOOD

536.461

8700. Measurement of the velocity of combustion by the soap-bubble method. G. PANNETIER, M. LECAMP AND A. SICARD. *J. Chim. phys.*, **52**, *No.* 4, 347–51 (*April*, 1955) In French.

Schlieren photographs of the expansion of a flame front in hydrocarbon-NO mixtures were taken by a rotating-drum camera. Special features of the technique were the use of single achromatic lenses to reduce light losses in the optical system, and direct recording of time intervals on the photographic film by interruption of a beam of light through a perforated disk driven by a synchronous motor. A high proportion (50–60%) of results must be discarded because of experimental failures of various sorts; those retained show, in a typical example, a standard deviation of 5% about the mean. A. SCHOFIELD

536.48

8701. Thermodynamics of the lambda-point. P. VAN DER LEEDEN. *Physica*, **21**, *No.* 7, 561–4 (*July*, 1955).

Formulae are given for the jumps in d^2p/dt^2 and dr/dt occurring at the λ-point on the vapour-pressure curve of helium. It is shown that the formulae may be useful in drawing the $p(t)$ and $r(t)$-curves. A.

536.48

8702. The viscosity of liquid helium II. W. J. HEIKKILA AND A. C. HOLLIS-HALLETT. *Canad. J. Phys.*, **33**, *No.* 8, 420–35 (*Aug.*, 1955).

It has been found possible to use the rotating cylinder viscometer to measure the viscosity of liquid helium II between 1·13°K and 2·18°K provided that the fluid velocities do not exceed about $0{\cdot}08\,cm.sec^{-1}$. The results, which are calculated directly from experimental observations and do not require any knowledge of the density of the normal component, can be made to fit the Landau and Khalatnikov theory for the temperatures below 1·8°K for which the theory is applicable. The results are somewhat higher than the oscillating disk results above 1·4°K. A.

536.48

8703. Transition temperatures of He^3–He^4 solutions. J. G. DASH AND R. D. TAYLOR. Letter in *Phys. Rev.*, **99**, *No.* 2, 598–9 (*July* 15, 1955).

Experiments consist in measuring the time period of a torsion pendulum immersed in liquid helium. By plotting the period against the temperature the λ-point $[T_0(0)]$ can be located as a kink with an accuracy of more than 0·05%. By similar measurements with mixtures of isotopes the transition point $[T_0(x)]$ is found as a function of the mole fraction (x). Results at 3 different concentrations are in good agreement with the formula $T_0(x)/T_0(0) = (1 - x)^{2/3}$. R. EISENSCHITZ

536.48 : 532.133

8704. Experimental verification of Landau's formula for the determination of the coefficient of viscosity of liquids by the method of damped torsional oscillations of a disk. G. A. GAMTSEMLIDZE. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 3, 441–4 (1955) In Russian.

Model tests with distilled water show that Landau's correction for disk thickness is valid under conditions under which the viscosity of helium II has been determined by E. L. Andronikashvili [Abstr. 3945 (1949)] and later investigators using the disk oscillation method. The discrepancy between Andronikashvili's results and those obtained by Hollis-Hallett [Abstr. 8374 (1953)] using the rotating cylinder method and those calculated by Zinov'eva [Abstr. 6988 (1955)] from data on second sound velocity is thought to be due to the intrinsic properties of helium II. A. GELBTUCH

536.48 : 536.7

8705. Phase transitions of the first and second orders. C. HURST. *Proc. Phys. Soc. B*, **68**, *Pt* 8, 521–5 (*Aug.*, 1955).

A second-order differential equation in the variables p and T is obtained which is valid for all phase equilibria of the first and second orders. On the basis of this equation, Ehrenfest's treatment of second-order

phase changes is presented as a degenerate case of first-order transitions involving discontinuous changes of volume which are very small but non-zero. The ensuing discussion, in which special reference is made to the case of liquid helium, indicates how a fuller understanding of the nature of a second-order transition can be achieved by regarding it as the limiting case of a first-order transition. A.

536.48

8706. Rotation of liquid helium. L. D. Landau and E. M. Lifshits. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 4, 669–72 (1955) In Russian.

The depth of the meniscus during the rotation of liquid helium has been found to correspond to the rotation of the whole liquid, and not of its "normal" portion only. This finding, apparently contradicting the theory of helium II, is explained as follows. Since neither the transition of helium II into helium I nor the rotation of helium I alone is thermodynamically advantageous, it is assumed that, during rotation, the normal He rotates as a whole, while, as far as superfluid motion is concerned, the cylindrical volume of the liquid is divided into a number of coaxial cylindrical layers the boundaries between which represent the surfaces of tangential ruptures of superfluid velocity. The thickness of the layers has been derived for both the slow and rapid rotation. For velocities of 8–16 rev/sec and assuming the speed of second sound to be $u \sim 20$ m/sec, the calculated layer thickness is 0·05 cm. See also Abstr. 7956 (1950).

F. LACHMAN

536.48

8707. Flow of helium II through narrow slits. D. H. N. Wansink, K. W. Taconis, F. A. Staas and J. Reuss. Letter in *Physica*, **21**, *No.* 7, 596 (*July*, 1955).

The rate of flow at uniform temperature was measured as a function of the pressure head. The slit had a width of $0{\cdot}2\,\mu$; the pressure head was varied from the saturation pressure to 1 atm. Measurements are made at temperatures from 1·25 to the λ-point. It is found that the pressure head is proportional to an oblique power (3·9) of the rate of flow, the factor of proportionality depending on the temperature.

R. EISENSCHITZ

536.48

8708. The transport of heat through narrow channels by liquid helium II. P. G. Klemens. *Austral. J. Phys.*, **8**, *No.* 2, 206–11 (*June*, 1955).

In narrow channels ($\sim 10^{-4}$ cm) the observed heat transport is considerably larger than calculated by the internal convection theory. It is suggested that, because of the anisotropy of the distribution of phonons in the channel walls resulting from the temperature gradient, the normal fluid in the immediate vicinity of the walls is not at rest but flows towards the colder region. The magnitude of the resulting heat transport is in reasonable agreement with the observed discrepancy. A.

536.48

8709. Heat transfer in liquid helium below 1°K. H. A. Fairbank and J. Wilks. *Proc. Roy. Soc. A*, **231**, 545–55 (*Sept.* 20, 1955).

The thermal conductivity of liquid helium has been measured between 0·2 and 1·0°K. Below 0·6°K the heat flow is exactly proportional to the temperature gradient and the thermal conductivity is proportional to the specific heat and the diameter of the specimen. Thus the sole mechanism of heat transfer appears to be by phonons which are scattered only at the boundaries of the specimen. These results are in satisfactory accord with previous theoretical discussions and with measurements of the propagation of heat pulses in the liquid. The experiment also afforded the opportunity of making subsidiary measurements of the thermal resistance of the boundary between a metal and liquid helium. Besides being of practical importance, the results show that some modification is called for in the existing theoretical treatments. A.

536.483 : 538.24

8710. Magnetic cooling. E. Ambler and R. P. Hudson. *Rep. Progr. Phys.*, **18**, 251–303 (1955).

After an historical introduction the general principles of the magnetic cooling method are outlined. First, the case of the ideal paramagnetic salt is treated, and this is followed by a discussion of the electric and magnetic interaction effects which cause departures from ideal behaviour, and set a lower limit to the temperatures which can be reached upon adiabatic demagnetization. A description of experimental techniques and procedures includes the subjects of cryostat and magnet design. The methods which have been used to establish the absolute temperature in the range below 1°K are surveyed and a summary of the results obtained is presented. Apart from their usefulness as coolants and thermometers, paramagnetic salts have intrinsically interesting thermal and magnetic properties, e.g. specific heat anomalies and hysteresis effects, associated with the internal ordering which proceeds as the temperature approaches the absolute zero. These properties are discussed in a separate section; another deals with the properties of other substances in the region below 1°K—mainly metals and liquid helium. A section is also included on the difficult problems associated with providing adequate thermal insulation for a low temperature system on the one hand, and thermal contact within such a system on the other. The comparatively new developments of cascade demagnetizations and continuous cooling cycles are described. Finally, the principles involved in a recent striking application of the magnetic cooling method, viz. the spatial orientation of atomic nuclei, are outlined. Extensive bibliography. A.

536.581

8711. Design and construction of two low-temperature thermostats. A. Gilchrist. *Rev. sci. Instrum.*, **26**, *No.* 8, 773–5 (*Aug.*, 1955).

Two small thermostats for use in the temperature ranges −40 to −70°C and −70 to −150°C are described. The controlling element in both cases is a thermocouple used in conjunction with a potentiometer and galvanometer-photomultiplier amplifier. The higher-temperature thermostat uses an acetone bath as the immersion medium while the lower temperature one uses a metal block for this purpose. Temperature control to within 0·01 deg C may be attained with both thermostats if reasonable care is taken in correcting for the normal drift in the potentiometer calibration which occurs over periods of time greater than an hour. A.

536.628.2 : 541.64

8712. Calorimetry of high polymers. III. A new type of adiabatic jacket and calorimeter. A. E. Worthington, P. C. Marx and M. Dole. *Rev. sci. Instrum.*, **26**, *No.* 7, 698–702 (*July*, 1955).

For Pt II, see Abstr. 1743 (1952). Describes a new type of adiabatic jacket and a modified calorimeter designed especially for the measurement of the specific heats of high polymers in the range −20 to +300°C. New features of the adiabatic jacket include the use of two dissimilar metals to increase temperature uniformity and a new method of closing and controlling the temperature of the ends. Calibration data using Al_2O_3 had an average precision of ±0·07%, although the uncertainty in an individual measurement, while ±0·1% up to 160°C may reach ±0·5% at 300°C. Further studies of the use of an alternating current watt-hour meter in calorimetry are reported. A.

536.631

8713. Specific heat anomaly of ferroelectric cadmium niobate at the Curie temperature. H. R. Danner and R. Pepinsky. *Phys. Rev.*, **99**, *No.* 4, 1215–17 (*Aug.* 15, 1955).

The anomalous specific heat of ferroelectric $Cd_2Nb_2O_7$ has been measured in the region of its Curie temperature, $T_c = 193$°K, using a vacuum adiabatic calorimeter. The values of the transition energy and the transition entropy change are 18 ± 2 cal/mole and 0·09 ± 0·01 cal/deg.K-mole, respectively. A comparison between the experimental values of the transition entropy change, the spontaneous polarization and the Curie constant is made. A.

536.631 : 541.113

8714. Atomic heat of graphite between 1 and 20°K. P. H. Keesom and N. Pearlman. *Phys. Rev.*, **99**, *No.* 4, 1119–24 (*Aug.* 15, 1955).

The atomic heat of pure artificial polycrystalline graphite has been measured between 1 and 4°K and 10 and 20°K. Precautions were taken to ensure that no error was introduced by gas adsorbed on the graphite. Below 2°K the atomic heat can be represented as the sum of a term proportional to T^3 arising from low-frequency lattice waves and a term proportional to T due to electrons: $C = 0{\cdot}0325T^2 + 0{\cdot}031T$ millijoules/mole degree. Between 2·25°K and 4·5°K, $C = 0{\cdot}115T^2 + 0{\cdot}031T - 0{\cdot}237$ millijoules/mole degree; between 10 and 20°K, $C = 0{\cdot}208T^2 - 6{\cdot}8$ millijoules/mole degree. A.

536.66

8715. On the heat of dissociation of N_2. J. F. Burns. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1347 (*July*, 1955).

From an investigation of the ionization efficiency curve for the N^+ ion from N_2 it is concluded that both the atom and ion resulting from the dissociation of N_2 by electron impact are formed in their ground states at onset. A first upward break at 1·9 eV and a second at 2·4 eV above onset are observed. W. Good

536.66

8716. Heat of formation and entropy of titanium tetrachloride from an investigation of the equilibrium: $TiO_2(s) + 4HCl(g) = TiCl_4(g) + 2H_2O(g)$. M. Farber and A. J. Darnell. *J. chem. Phys.*, **23**, *No.* 8, 1460–3 (*Aug.*, 1955).

The equilibrium, TiO_2(rutile) + 4HCl = $TiCl_4(g)$ + $2H_2O(g)$, was studied in the temperature range of 800–1 400°K by means of a flow method in which HCl was passed over a sample of rutile. The heat of reaction was found to be 12·9 kcal/mole in this temperature range. This leads to a value of −182·9 ± 0·5 kcal/mole for ΔH_f of $TiCl_4(g)$ and −192·5 ± 0·5 kcal/mole for ΔH_f of $TiCl_4(l)$. The entropy of $TiCl_4(g)$ at 1 100°K is found to be 124 cal/°/mole. A.

THERMODYNAMICS 536.7/.8

536.7

8717. Mathematical foundations of the thermodynamics of irreversible processes. K. Popov. *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 257–82 (1955) In Russian.

It is assumed that the entropy defect in non-equilibrium (ΔS) can be expressed as a function of a number of independent variables $x_1, x_2 \ldots$, which are zero in equilibrium but are otherwise not specified. In the neighbourhood of equilibrium $-2\Delta S = \Sigma\Sigma g_{ik}x_ix_k + 0(x_i^3)$ and $g_{ik} = g_{ki}$. The change in time of the independent variables is supposed to obey Newton's equations of motion $d^2x_i/dt^2 = x_i$ where the "force" is given by $X_i = \Sigma g_{ij}x_j$. Integration gives $x_i = a_i \exp(rt)$ where r^2 is an eigenvalue of the matrix g_{ik}. By the second law of thermodynamics only negative values of r are admitted. It is deduced that $dx_i/dt = \Sigma L_{ik}X_k$. In irreversible thermodynamics these equations are usually introduced *ex hypothesi*. According to the present paper the matrix elements L_{ik} are uniquely determined by the matrix elements g_{ik}. For the case of two independent variables Onsager's reciprocity relations $L_{ik} = L_{ki}$ are established by direct calculation. For three or more independent variables an indirect proof of Onsager's relations is given. Their validity as relations between the second-power terms in the expansion of ΔS is preserved, if higher powers of this expansion are taken into account. R. Eisenschitz

536.7

8718. On Onsager's phenomenological relations. Kh. Karanikolov. *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 283–6 (1955) In Russian.

See preceding abstract. The symmetry relation $L_{ik} = L_{ki}$ is proved by direct calculation in the case of three independent variables. R. Eisenschitz

536.7 : 533.7

"Virial theorem" for the flow of energy. *See Abstr.* 8553

536.71

8719. Thermodynamics of two-phase systems. P. van der Leeden. *Physica*, **21**, *No.* 7, 545–53 (*July*, 1955).

The thermodynamics of higher-order transitions has caused considerable discussion without notable agreement. As controversies still exist it is worth while to give a more systematic outline than has been

given up to now, especially as the experimental evidence is growing rapidly. This paper is restricted to the study of systems in equilibrium, consisting of one component and two phases and one type of work only. The actual occurrence of the systems studied plays a minor rôle only. Taylor series of the Gibbs's functions are applied systematically to study the contact relations between the thermodynamic potentials. It is shown that mathematically second order lines are a much more "exceptional" state of affairs than isolated second or higher order points on first order lines. The notion of double-point is introduced and an application mentioned. As a by-product several relations involving higher order derivatives of transition-lines are found. A.

536.71

8720. On triple points. P. VAN DER LEEDEN. *Physica*, **21**, *No.* 7, 554–60 (*July*, 1955).

Neither relations between higher order derivatives of transition lines nor relations for triple points formed with one or more transition lines of higher order seem to have been discussed systematically. The consequence of a triple point being at the same time a higher order point on an elsewhere lower order transition line has been considered only in part. An attempt at a systematic survey of the possibilities is made here. The different cases are discussed in the order of their likelihood from a mathematical point of view. Whether the diagrams considered occur in practice is of little interest here. A.

536.71

8721. Equations of state of elements from the Thomas–Fermi theory. N. H. MARCH. *Proc. Phys. Soc. A*, **68**, *Pt* 8, 726–34 (*Aug.*, 1955).

An investigation of the equations of state of elements as given by the Thomas–Fermi theory has been carried out in a region corresponding to higher pressures than have hitherto been discussed in detail. Both analytical and numerical methods have been used. The results thus obtained suggest modifications to be made in the formulae given by Gilvarry [Abstr. 1127 (1955)], who fitted the available numerical data with functions having the correct limiting forms. The introduction of exchange is also considered and the modifications thus caused are exhibited explicitly for very high pressures. A.

536.75

8722. The entropy of a system consisting of a random number of particles. R. L. STRATONOVICH. *Zh. éksper. teor. Fiz.*, **28**, *No.* 4, 409–21 (1955) In Russian.

In a small volume within a fluid the number of molecules is subject to random fluctuations. In attempting to assign to this, or any similar, system an entropy the author rejects the obvious expression depending upon the mean number of particles. The term "entropy" is, in fact, used in accordance with the conventions of communication theory and not related to any thermodynamical property. An expression for the "correct" entropy is obtained in terms of quantities to be derived from the distribution functions in phase space which need not necessarily correspond to thermal equilibrium. The physical significance of the result is not disclosed.

R. EISENSCHITZ

ELECTRICITY 537

537.12 : 539.153

8723. The calculation of the electric elementary charge from the energy quanta model. H. ZUHRT. *Arch. elekt. Übertragung*, **9**, *No.* 4, 181–91 (*April*, 1955) In German.

Following the energy quanta model set up previously, an electron model is developed and the energy taken by this model from an electrostatic field is computed. The case considered is the simplest combination of energy quanta. The constant e, appearing in the well-known formulae for the energy taken by an electron in a constant field, is found and the electric elementary charge is computed. It also seems possible that atoms could be built up from this energy quanta model by synthesis of further energy quanta and electrons. This means a new atom model which, unlike the Bohr atom model, contains no indefinite intermediate spaces and is definable through closely bound parts, their concentration and quantity; thus the derivation of quantitative results from this model is made possible, exactly as for the case of an electron. The deviation of 7·7% between the calculated and experimental values for e is attributed to approximations used in numerical computation. Z. F. WOJNAR

537.122

8724. On the physical interpretation of electron self-acceleration. K. WILDERMUTH. *Z. Naturforsch.*, **10a**, *No.* 10, 450–9 (1955) In German.

The point-electron is regarded as the limit of a model of finite extension. The total mass is expressed as the sum of mechanical and electromagnetic parts, and it is shown that self-acceleration is possible for negative mechanical mass. R. A. NEWING

ELECTROSTATICS . DIELECTRICS 537.2

537.221

8725. Charge acquired by powdered salts on moving over metal surfaces. B. A. COOKE. Letter in *Nature* [*London*] **176**, 264 (*Aug.* 6, 1955).

Particles were allowed to slide down an earthed aluminium chute. The results showed that an adsorbed moisture film on the surface of particles of an ionic salt (e.g. NaCl) increased the amount of charge generated. For tiny glass spheres the converse was true. Also the charge on glass spheres covered by a moisture film, soon reached a limiting value when the amount of sliding was increased, but this was not evident for the ionic salts under the same conditions. The results for ionic salts contradict the common principle that appreciable electrification accompanies friction between two surfaces only if one or both of them has a low electrical conductivity. It is suggested that charge separation between an ionic salt and metal is mainly due to ion transfer whereas the electrification rule has been based on systems where electron transfer is predominant. A. E. KAY

537.221 : 539.61

8726. Adhesion and charging of quartz surfaces. W. R. HARPER. *Proc. Roy. Soc. A*, **231**, 388–403 (*Sept.* 6, 1955).

Very large charges are obtained from the light contact of two crystal faces of quartz with each other, an X cut face being positive with respect to a Z cut. The effect is not piezoelectric in origin, since it does not reverse when an X_- face is used instead of an X_+. The not inconsiderable charges obtained using vitreous silica may be due to patches of incipient crystallization. The tendency of well-cleaned quartz and silica surfaces to adhere seems not to affect the charging, and the adhesion is not electrical in origin. It is unlikely that electrostatic forces ever contribute appreciably to the force of friction. A.

537.226

8727. The high temperature susceptibility of a lattice of permanent dipoles. B. K. P. SCAIFE. *Phil. Mag.*, **46**, 903–10 (*Aug.*, 1955).

Pople's criticism [Abstr. 429 (1954)] of the results obtained, for the high temperature susceptibility of a permanent dipole lattice, by Van Vleck and by Rosenberg and Lax [Abstr. 3428 (1953)] is shown to be unjustified. Two alternative derivations are given of the relations obtained by Van Vleck *et al.* It is shown that Kirkwood's correlation parameter, g, depends upon dipole–dipole interactions. A.

537.226.1

8728. Solid mixture permittivities. W. F. BROWN, JR. *J. chem. Phys.*, **23**, *No.* 8, 1514–17 (*Aug.*, 1955).

A macroscopically homogeneous aggregate contains two materials A, B, with dielectric constants ϵ_A, ϵ_B, in volume ratio $p : (1-p)$; what is the dielectric constant of the aggregate? By a method used by Yvon and others in molecular theory, this very old problem is formulated rigorously and solved in series form. One form of the solution is $\epsilon/\epsilon' = 1 + \frac{1}{3}p(1-p)(\delta'/\epsilon')^2 + \ldots$, where $\epsilon' = p\epsilon_A + 1(-p)\epsilon_B$, $\delta' = \epsilon_A - \epsilon_B$. The cubic and higher terms depend on statistical properties of particle geometry: namely, on such functions as $p^{(3)}_{123}$, the probability that three specified points 1, 2, 3 are all in material A. The relation to earlier calculations is discussed. A.

537.226.1.08 : 538.083

8729. Measurements on dielectric and ferromagnetic materials at frequencies around 10^4 Mc/s. G. KLÄTTE. *Fernmeldetech. Z.* [*FTZ*] **8**, *No.* 5, 256–61 (*May*, 1955) In German.

Describes methods using a standing wave indicator for measuring the complex relative dielectric constant of solid materials in the temperature range 20–160°C, and for measuring the complex relative permeability of ferromagnetic materials at room temperature. The results of dielectric measurements on six plastic materials and three magnetic materials are given in tables and graphs. A. E. DE BARR

537.226.2 : 621.3.011.5 : 621.315.615

8730. Dielectric behaviour of six normal primary alcohols between −60° and +60°C at 1·25 cm wavelength. C. BROT. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 20, 1989–91 (*May* 16, 1955) In French.

Curves of ε' and ε'' against temperature are shown for *n*-hexanol-1, *n*-heptanol-1, *n*-octanol-1, *n*-nonanol-1, *n*-decanol-1 and *n*-dodecanol-1. Below their freezing-points, the alcohols have ε' values in the range 2·25–2·40 and ε'' values $< 0{\cdot}01$. A sharp rise of 0·1–0·15 occurs in both ε' and ε'' on melting, followed by a smooth rise in both of about 0·4 per 100 deg C rise of temperature thereafter.

F. F. ROBERTS (R)

537.226.2

8731. About the problem of the molecular theory of ferroelectrics. G. A. SMOLENSKIĬ AND R. E. PASŸNKOV. *Zh. éksper. teor. Fiz.*, **25**, *No.* 1(7), 57–73 (1953) In Russian.

Contemporary molecular theories of ferroelectricity are reviewed. A general form of the local minima model is discussed. There phase transitions correspond to the critical Curie point. Low-temperature phase transitions are investigated. Properties of barium titanate are not explained satisfactorily by the model with a constant number of local minima for all temperature ranges. The existing method of calculation, based on the application of the anharmonic oscillator model, is shown to be identical with the application of the thermodynamic displacement theory for calculation of free energy of association of anharmonically oscillating ions. Several properties of ferroelectrics depend on fluctuations of displacements of these ions. The possibility of application of the anharmonic oscillator model to other crystals with perovskite type structure is considered.

J. LUKASZEWICZ

537.226.2

8732. Electrical behavior of barium titanate single crystals at low temperatures. H. H. WIEDER. *Phys. Rev.*, **99**, *No.* 4, 1161–5 (*Aug.* 15, 1955).

Barium titanate single crystals have electrical characteristics in the orthorhombic and rhombohedral phases which are similar to those observed in the tetragonal region. At a phase transition the coercivity, determined from 60 c/s hysteresis loops, decreases sharply from its value at temperatures above the transition. Correspondingly, the polarization reversal time and the spontaneous polarization decrease discontinuously from the values above the transition. All of these phenomena are accompanied by thermal hysteresis. A plot of the dielectric constant as a function of switching time is a straight-line relation and supports the theory of a relaxation-type mechanism for polarization reversal. A.

537.226.33 : 533.7

8733. Inertial effects and dielectric relaxation. E. P. GROSS. *J. chem. Phys.*, **23**, *No.* 8, 1415–23 (*Aug.*, 1955).

The study of dielectric relaxation in compressed gases requires an extension of existing theory. As the gas pressure is lowered below several hundred atmospheres, the inertial response of the dipoles gives rise to large deviations from the Debye equations. The absorption and dispersion depend on collision time and frequency of applied field in a manner which is sensitive to the molecular constants and to the state of dynamical order of the compressed gas. These phenomena are investigated by studying the response to an alternating electric field of a dilute solution of dipolar molecules in a non-polar compressed gas. The dipoles are described by a classical distribution

function which is a function of angular velocity, orientation, and time. It is assumed that the duration of collision may be neglected compared to the time between collisions, the period of the applied field, and the mean thermal period. The distribution function satisfies a kinetic equation; the effects of collisions are described by a collision kernel. One kernel yields a soft impact theory which is a generalization of Debye's Brownian motion treatment to include inertial effects. The complex polarization is given in the form of a convergent infinite continued fraction. Other models studied involve strong collisions and partial specular reflection. A common feature of all models is that the Debye relaxation shape is found at high pressures. Inertial corrections are important in the region between one and a few hundred atmospheres; the corrections depend on the model. Another common feature is the way in which the discrete rotational lines are linked with the Debye spectrum. The collision frequency $1/\tau$ increases with increasing gas pressure; at low pressures it is proportional to the width of a rotation line. At high pressures when the Debye shape is found, the relaxation time t^* is given by $t^* = 1/\tau(I/kT)$. Here I is the moment of inertia of the dipole, k is Boltzmann's constant, and T is the temperature of the reservoir. Thus the relaxation time varies inversely with time between collisions. The physical reason is that collisions hinder the drift motion of the dipoles which is the cause of the relaxation of the polarization. At lower pressures the main contribution to the polarization arises from dipoles rotating with an angular frequency close to that of the applied field. This is related to the known result that the main contribution to the static polarization is from librating dipoles. A.

537.226.33 : 548.7

8734. Dielectric relaxation for spherical molecules in a crystalline field: theory for two simple models. J. D. Hoffman and B. M. Axilrod. *J. Res. Nat. Bur. Stand.*, **54**, *No.* 6, 357–63 (*June*, 1955).

A theory of dielectric relaxation is given for two simple models where the dipoles may occupy orientational sites arranged in three dimensions. In the first model, the dipole may point toward the corners of a regular tetrahedron, and in the second, toward the faces of a cube. Both models are simplified to the extent that only one of the sites can differ in energy from all the others. The calculations show that these models lead to a discrete set of dielectric relaxation times when the sites are not equivalent. The effect of the set of relaxation times on the characteristics of the dielectric relaxation spectrum is examined. The relaxation times are always sufficiently close together so that the dielectric loss is confined to a single region. However, the separation of the relaxation times is sufficient to cause the dielectric loss peak to be considerably broader than that predicted by the Debye equations. In addition, it is found that the loss maximum will frequently be asymmetrical. The variation of the dielectric constant with temperature, and the breadth and asymmetry of the loss peaks are discussed. A.

537.226.8

8735. Alteration of the dielectric permeability of phosphors under the influence of infrared light. E. E. Bukke. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 4, 507–8 (1955) In Russian.

Investigations at wavelengths of 0·8 and 1·3 microns show that for a group of ZnS phosphors, only those which are optically excited show a change in the dielectric properties. J. M. HOUGH

537.228.1

8736. Some applications of the piezoelectric equations of state. R. Bechmann. *Arch. elekt. Übertragung*, **9**, *No.* 3, 122–30 (*March*, 1955) In German.

The general linear piezoelectric equations are specialized for application to plates and thin bars of finite or infinite extent and are used to investigate the theoretical relationships in systems comprising (i) 3 finite stresses, 2 normal and 1 shearing, in a plane; (ii) 3 finite strains, 1 normal and 2 shearing, perp. to a plane; and (iii) 1 normal stress. The discussion includes the relationship between the dielectric constant at constant stress and constant strain and also the 1-, 2- and 3-dimensional coupling factors and their bearing on the vibrations of plates and bars. H. J. H. STARKS

537.228.1

8737. The dynamic measurement of the piezoelectric constants of $BaTiO_3$. P. Buriánková. Letter in *Czech. J. Phys.*, **5**, *No.* 2, 276–9 (*April*, 1955) In Russian.

A procedure for measuring the series and parallel resonant frequencies of a flat plate of polycrystalline $BaTiO_3$ is outlined. The piezoelectric constant d of the material is then calculable using additional quantities which are easily measured. Typical curves of the variation of resonant frequency with temperature and of the dependence of d on the duration of polarization, the magnitude of the polarizing field, the ambient temperature during polarization and the passage of time are given. A. L. MACKAY

ELECTRIC CONDUCTION . CURRENTS 537.3

537.311.1

8738. Generalizations of Brillouin flow. L. R. Walker. Letter in *J. appl. Phys.*, **26**, *No.* 6, 780–1 (*June*, 1955).

Steady flow in a uniform d.c. H-field is supposed to be established such that charge density is constant and, for each electron, the sum of potential and kinetic energies is zero. With these restrictions, equations are derived containing a certain parameter ω_p. For different values of ω_p, orbits can be circles, ellipses or hyperbolae; plane Brillouin flow is derived as a special case. Each flow can be regarded as a superposition of circular and hyperbolic flows; the equipotentials are always elliptical. N. M. KING

537.311.31

8739. Electron transport in copper and dilute alloys at low temperature. III. Solid solutions of iron in copper. W. B. Pearson. *Phil. Mag.*, **46**, 911–19 (*Aug.*, 1955).

Pts I and II to be published in *Acta Metallurgica* (in press). Systematic measurements of thermoelectric force and electrical resistivity of dilute alloys of iron in

copper have been made at close intervals of temperature between 4·2 and ~50°K. These show that iron gives rise to particularly large anomalous thermoelectric effects and minima in the resistance when dissolved in copper. The anomalous resistive component calculated by methods described does not follow an exponential or power law dependence on temperature, but, within certain limits, follows an empirical law dependent on a characteristic temperature. Taken at its face value this would suggest that the resistance minimum, in this case at least, is the result of some transition phenomenon. The size of the resistance minimum in these alloys is notable; for instance, the anomalous increase in resistivity between 27 and 4·2°K in an alloy containing 0·044 atomic % Fe is equal to the thermal scattering component found in pure copper at about 50°K. A.

537.311.31

8740. Electron transport in copper and dilute alloys at low temperature. IV. Resistance minimum: temperature of occurrence as a function of solute concentration. W. B. Pearson. *Phil. Mag.*, **46**, 920–3 (*Aug.*, 1955).

The temperature (T_{min}) has been determined at which the resistance minimum occurs for a large number of dilute copper alloys containing Fe, Ga, In, Si, Ge, Sn, Pb and Bi as solutes. Data on the absolute thermoelectric power and size of the resistance minimum of these alloys have previously been published. For alloys of Fe, Bi and Pb, it was found that $(T_{min})^n \propto r_C$ where $n \sim 5$ and r_C is the normal residual resistivity increase due to the added solute. The variation of T_{min} with solute concentration is much small for Ga, In, Ge and Sn as solutes than for Fe, Bi and Pb. A.

537.311.31 : 537.533.2

8741. The kinetic temperature of electrons in metals, and anomalous electronic emission. V. L. Ginzburg and V. P. Shabanskiĭ. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 3, 445–8 (1955) In Russian.

Contains a discussion of conduction in metals at high field strengths based on simple physical considerations. It is shown that for the case of electron–electron collisions the symmetric part of the distribution function still has the Fermi–Dirac form, with a "temperature" higher than that of the lattice; and further that this effect may be important in the quantitative treatment of electron emission at high current densities. J. M. RADCLIFFE

537.311.31 : 539.185.9

8742. Radiation induced changes in the electrical resistivity of α brass. D. B. Rosenblatt, R. Smoluchowski and G. J. Dienes. *J. appl. Phys.*, **26**, *No.* 8, 1044–9 (*Aug.*, 1955).

Nucleon irradiation of metallic solid solutions may lower their resistivity by changing the degree of randomness (tendency to order or to cluster) or by a change of elastic moduli. Measurements of resistivity of brasses containing 10, 20 and 30% zinc have been performed at room temperature, at 80 and at 4°K. The alloys were irradiated in a reactor at +50°C and at 80°K. It appears that the results can be best interpreted in terms of the formation of lattice defects upon low temperature exposure and increase of short-range order upon irradiation at +50°C. The change of residual resistivity is negative while the change of resistivity due to thermal scattering is positive for the samples irradiated at +50°C. The former depends upon irradiation flux and upon annealing time in a different manner from the latter. Short-range order appears to be produced also by proper heat treatment. A.

537.311.31 : 548.7

8743. The effect of holes in a crystal lattice on the electric resistance of a metal. B. G. Lazarev and O. N. Ovcharenko. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 5, 875–8 (1955) In Russian.

It is pointed out that holes may be formed in a metal lattice by heating it to a fairly high temperature, and then "frozen" in the lattice by rapid cooling to a temperature at which the hole diffusion coefficient is small. The holes will then cause an additional electric resistance. Measurements were made on gold and platinum wire heated electrically to various temperatures. The relations obtained are in agreement with the theoretical formulae, thus favouring the hypothesis that holes actually exist, and that the extra resistance is not due to deformations arising on cooling, which would give a different relation. The disappearance of holes from the metal on annealing at various temperatures is in accordance with a diffusion mechanism. The heats of formation of holes, their concentration, and their diffusion coefficient are calculated for gold and platinum.

J. B. SYKES

537.311.32 : 538.221

8744. Relation of magnetic structure to electrical conductivity in NiO and related compounds. R. R. Heikes. *Phys. Rev.*, **99**, *No.* 4, 1232–4 (*Aug.* 15, 1955).

A qualitative theory is presented in an effort to understand the insulating properties of NiO. If one generalizes this theory to include all stoichiometric binary compounds, having a transition element as cation and an element from group V or VI as anion, a rather startling correlation between the magnetic and electric properties is predicted. Ferromagnetic compounds should be good conductors with a positive temperature coefficient of resistivity while antiferromagnets should be insulators with a negative temperature coefficient of resistivity. The available data indicate that this correlation does exist. A.

537.311.33

8745. The theory of the Hall and Nernst–Ettingshausen effects in semiconductors [in the region] of mixed conduction. F. G. Bass and I. M. Tsidil'kovskiĭ. *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 312–20 (1955) In Russian.

The Hall voltage, Nernst–Ettingshausen voltage, and carrier concentration as a function of position are calculated for a semiconductor in an inhomogeneous magnetic field when it is in the region of mixed conduction. The presence of impurity levels, and recombination, is taken into account.

J. M. RADCLIFFE

537.311.33

8746. Measurement of minority carrier lifetimes in semiconductors. N. F. DURRANT. Note in *Proc. Phys. Soc. B*, **68**, *Pt* 8, 562–3 (*Aug.*, 1955).

A method suitable for germanium or silicon filaments is described in which a pulse of minority carriers is injected at an emitter and a sweeping pulse is applied later in time and the collector signal is displayed on a c.r.o. The method essentially measures local lifetime near the emitter.

C. A. HOGARTH

537.311.33

8747. Scattering of electrons and holes by charged donors and acceptors in semiconductors. R. B. DINGLE. *Phil. Mag.*, **46**, 831–40 (*Aug.*, 1955).

The problem of determining the time of relaxation due to scattering of electrons and holes by charged impurity donors and acceptors in semiconductors is reconsidered in an effort to derive formulae more exact and general than those due to Conwell, Weisskopf and other authors. A.

537.311.33

8748. Hot electron problem in semiconductors with spheroidal energy surfaces. M. SHIBUYA. *Phys. Rev.*, **99**, *No.* 4, 1189–91 (*Aug.* 15, 1955).

Shockley has derived the expression $E_c = (1{\cdot}51)C_l/\mu$ for the critical electric field strength E_c at which the current-voltage relation in a semiconductor departs from Ohm's law. Here C_l is the velocity of longitudinal phonons and μ the conductivity mobility of the carrier. Experimental values of E_c for Ge and Si are from two to four times larger than those predicted by this formula. The theory has therefore been extended to take into account ellipsoidal energy surfaces in the Brillouin Zone and scattering by shear modes of vibration. The effect of the more general effective mass tensor is to raise the theoretical value of E_c by a factor of about 2 for *n*-type Ge and 1·3 for *n*-type Si, whereas shear mode scattering lowers E_c by a factor that is between 1 and the value of the ratio of transverse modes to that of longitudinal modes. Moreover, E_c should vary with the direction of the current. The present study still fails to close the gap between theory and experiment: the remaining discrepancy is possibly the result of neglecting intervalley scattering. A.

537.311.33

8749. Recombination of injected carriers at dislocation edges in semiconductors. J. P. MCKELVEY AND R. L. LONGINI. *Phys. Rev.*, **99**, *No.* 4, 1227–32 (*Aug.* 15, 1955).

The boundary conditions for carrier recombination at a lineage boundary in a semiconductor in the presence of a constant electric field are derived from kinetic considerations. A non-recombination probability, or "transmission coefficient" T for a single charge is assumed initially, and "recombination velocities" at the lineage boundary are expressed in terms of this quality. A simple experiment to determine the transmission coefficient is suggested. The relationship between the transmission coefficient and the cross-section for recombination is investigated, and a relationship derived which permits one to calculate the actual recombination cross-section for a single dislocation, the density of dislocations in the lineage boundary having been experimentally determined. A.

537.311.33

8750. Fluctuations of the numbers of electrons and holes in a semiconductor. R. E. BURGESS. *Proc. Phys. Soc. B*, **68**, *Pt* 9, 661–71 (*Sept.*, 1955).

In calculations of certain types of noise in semiconductors it is required to know the fluctuation in the number of mobile charge carriers (electrons and holes). These fluctuations are calculated for a non-degenerate semiconductor in thermal equilibrium by two different methods: the first in terms of the electronic free energy of the system whose minimal properties are used to determine the equilibrium distribution and fluctuations of electrons between the conduction and valence bands and the impurity levels. The second approach is purely statistical and is based on the probabilities of the elementary processes of electron transitions between energy levels. The results of the two methods are identical but the thermodynamical method yields the solutions for complex cases which are not readily dealt with by the statistical method. Both intrinsic and extrinsic semiconductors are discussed, as well as the important practical case of a nearly intrinsic semiconductor. A.

537.311.33 : 548.7

8751. On lattice scattering in homopolar semiconductors. J. M. RADCLIFFE. *Proc. Phys. Soc. A*, **68**, *Pt* 8, 675–80 (*Aug.*, 1955).

The conductivity of a homopolar semiconductor with an arbitrary band shape is considered. The corresponding Boltzmann equation is solved after making a simplifying assumption about the form of the matrix element of the lattice-scattering potential. A.

537.311.33 : 621.315.59

8752. Use of electric field pulses as a method of investigating semiconducting films. H. RZEWUSKI AND L. SOSNOWSKI. *Bull. Acad. Polon. Sci. Cl.* 3, **3**, *No.* 2, 101–5 (1955).

The conductivity of microcrystalline films of PbS evaporated *in vacuo* in glass envelopes has been observed to be modulated by the application of a 200 c/s square-wave of voltage to an electrode on the outer surface of the glass, a balanced circuit being used to suppress direct capacitance coupling effects. The decay of the modulation during each half-cycle is interpreted in terms of the redistribution of the induced carriers between the conduction (or valence) band and the surface states. Some experimental results are given. F. F. ROBERTS (R)

537.311.33 : 536.2.01

The theory of the equation of transfer in a strong electric field. *See Abstr.* 8683

537.311.33 : 535.343

8753. On electrical and optical properties of silver telluride Ag_2Te. J. APPEL. *Z. Naturforsch.*, **10a**, *No.* 7, 530–41 (1955) In German.

Silver telluride undergoes a phase transition at 150°C associated with a strong variation in electrical properties. Measurements of electrical conductivity

and galvanomagnetic effects with temperature on the low temperature β-phase show a metallic binding. The addition of Group IV or V impurities has a marked affect on the carrier concentration and mobility. The α-phase shows conduction by electrons and by silver ions at high temperatures with an activation energy of 0·98 eV. The temperature dependence of mobility is discussed in terms of the Howarth–Sondheimer theory and leads to an effective electron mass of 0·4 m. The optical absorption edge is at about 1·85 μ corresponding to a 0·67 eV transition.

C. A. HOGARTH

537.311.33

8754. Semiconductivity of a Type IIb diamond. J. H. F. CUSTERS. Letter in *Nature* [*London*] **176,** 173–4 (*July* 23, 1955).

Semiconductivity is assumed due to a lattice defect of some kind and not an impurity. The energy gap is 0·70 eV from resistance-temperature measurements using a bridge technique (no potential probes) and the room temperature resistivity is $7{\cdot}1\times 10^5$ ohm. cm. There is a hysteresis effect during slow temperature cycling. The diamonds show point contact rectification.

C. A. HOGARTH

537.311.33 : 538.632

8755. Hall theory in *n*-type germanium. L. GOLD. Letter in *Phys. Rev.*, **99,** *No.* 2, 596 (*July* 15, 1955).

Universal plots based on recent band structure calculations are given for R_H (Hall coefficient) as a function of $\omega\tau$ where τ is an energy-independent scattering time and ω is given by

$$\omega = (qB/\bar{m}^*c)(3K/K+1)$$

where $K = m_1/m_2$, m_1 and m_2 are the mass tensor components, $\bar{m}^* = \frac{1}{3}m_1 + \frac{2}{3}m_2$ and B is the magnetic field. Experimental data lie between the above curves and curves based on the assumption of an energy-dependent τ.

C. A. HOGARTH

537.311.33 : 539.185.9

8756. Fast neutron bombardment of *p*-type germanium. J. W. CLELAND, J. H. CRAWFORD, JR AND J. C. PIGG. *Phys. Rev.*, **99,** *No.* 4, 1170–81 (*Aug.* 15, 1955).

Extensive studies of fast neutron bombardment effects in *p*-type Ge have been carried out. Analysis of the initial conductivity behaviour indicates the introduction of three vacant states below the middle of the forbidden band: (1) an acceptor state 0·18 eV above the valence band, (2) an occupied (donor) state which acts as a hole trap with a depth of ~0·07 eV, (3) a second low-lying donor which is a quite shallow hole trap. This distribution of energy levels is consistent with the Frenkel defect model of James and Lark-Horovitz. After prolonged bombardment or room temperature ageing, the ionization energy of bombardment-produced acceptors moves to lower values, a behaviour which has been attributed to a difference in annealing rate of interstitials and vacancies. The scattering mechanism for holes in bombarded specimens does not appear to be completely describable in terms of ionized impurity scattering. Moreover, the temperature dependence of hole mobility is quite different from electron mobility in bombarded specimens. Extensive bombardments in the range from −165 to −90°C are described and complex relaxation effects observed on warming are discussed.

A.

537.311.33

8757. Properties of grain boundaries in gold-doped germanium. A. G. TWEET. *Phys. Rev.*, **99,** *No.* 4, 1182–9 (*Aug.* 15, 1955).

It has been found that grain boundaries produce a path of relatively low electrical resistance at temperatures below ~100°K in Ge whose bulk resistivity has been made greater than 10^3 to 10^5 ohm. cm by the addition of Au. A new permanent-magnet apparatus for measuring the Hall effect in semiconductors at low temperatures is described. The results of measurement of the Hall effect as a function of temperature in Ge samples containing grain boundaries of known orientation are given. A peak in the Hall coefficient observed in some samples is discussed in terms of a crude model. Preferential conduction along grain boundaries also occurs in high resistivity Fe-doped Ge, but has not been observed in crystals containing coherent twin boundaries. A modification of Bardeen's theory of surface states is used in an attempt to account for the existence of the grain-boundary conduction phenomenon.

A.

537.311.33

8758. Hall effect and density of states in germanium. E. M. CONWELL. *Phys. Rev.*, **99,** *No.* 4, 1195–8 (*Aug.* 15, 1955).

The usual assumptions that underlie the analysis of Hall data to obtain activation energy and density of states are based on the simple model of the band structure. They are re-examined here in the light of the known band structure of germanium. In particular, consideration is given to the limits of validity of the assumption that carrier concentration equals $1/Re$. Also, energy levels of electrons bound to donors are investigated and it is shown that the effect of excited states, particularly for Sb-doped germanium, cannot be neglected. The density-of-states mass values obtained from Hall data for *p*- and *n*-type material are considered. In the latter case, the results are shown to favour a band edge at the surface of the Brillouin zone rather than inside.

A.

537.311.33

8759. Avalanche breakdown in germanium. S. L. MILLER. *Phys. Rev.*, **99,** *No.* 4, 1234–41 (*Aug.* 15, 1955).

It is shown that all germanium junctions studied break down as the result of the same avalanche process found in silicon. An empirical expression for the multiplication inherent in this breakdown process is given for step junctions. Ionization rates for holes and electrons in Ge are derived with the use of this expression. The ionization rate for holes is larger than that for electrons by about a factor of two. The agreement between these ionization rates as a function of field and the theory of Wolff is excellent. It is determined that the threshold for electron-hole pair production is about 1·50 eV and the mean free path for electron (or hole)-phonon collisions is about 130 Å.

A.

537.311.33

8760. Electrical properties of plastically deformed germanium. A. G. TWEET. *Phys. Rev.*, **99**, *No.* 4, 1245–8 (*Aug.* 15, 1955).

Samples of Sb-doped (10 ohm. cm *n*-type) and Au-doped (20 ohm. cm *p*-type) Ge have been plastically deformed at 550–620°C. The deformation created a large concentration of acceptor centres distributed inhomogeneously throughout the deformed sections of the samples. These acceptors lie near the valence band and converted the Sb-doped specimens to *p*-type. Hall coefficient measurements have been made as a function of temperature to determine the energies of these acceptors. Upon annealing at temperatures above 750°C from 30 minutes to 1½ hours, the acceptor levels near the valence band disappear, leaving only the acceptors probably associated with edge dislocations. It is postulated that the annealable acceptors may be due to the presence of vacancies. A.

537.311.33

8761. On the theory of the magnetic barrier layer in germanium. O. MADELUNG, L. TEWORDT AND H. WELKER. *Z. Naturforsch.*, **10a**, *No.* 6, 476–88 (1955) In German.

See Abstr. 3469 (1954). Detailed analysis of voltage-current characteristics for symmetrical and unsymmetrical configurations, and the effects of specimen size and surface recombination velocity are given. The frequency response and effects of light irradiation are also considered. C. A. HOGARTH

537.311.33

8762. Magnetic barrier layers in germanium. II. E. WEISSHAAR. *Z. Naturforsch.*, **10a**, *No.* 6, 488–95 (1955) In German.

See preceding abstract. The theory was tested experimentally. By means of pulse techniques currents up to 90 mA and voltages up to 60 V could be used. Good agreement between theory and experiment was found and suggested a linear recombination law for holes and electrons. End-injection was shown to play little or no part in the processes. Build-up and decay times for applied alternating fields were measured. C. A. HOGARTH

537.311.33

8763. Some implications of the small energy gap and small effective electron mass in InSb. J. W. ALLEN AND I. M. MACKINTOSH. *J. Electronics*, **1**, *No.* 2, 138–44 (*Sept.*, 1955).

The possible use of InSb as a source of infrared radiation, based on the apparent predominance of the photon-radiative recombination rate in this material, is discussed. Difficulties in the interpretation of very short lifetimes are noted, and a possible, new approach to problems of absorption edge transitions is described in terms of a recombination probability. An analysis of carrier diffusion in degenerate semiconductors indicates that the Einstein relation $D = \mu kT/e$ is not valid when dealing with very degenerate material, and a brief description is given of work in progress on the transition of the temperature-dependence of the mobility from the case of an intrinsic semiconductor to the case of a near-metal. A.

537.311.33

8764. Measurements of diffusion length in indium antimonide. D. G. AVERY AND D. P. JENKINS. *J. Electronics*, **1**, *No.* 2, 145–51 (*Sept.*, 1955).

Measurements of diffusion length by the light-spot method have been made for a range of samples of InSb, both *p*- and *n*-type. Values of carrier lifetime derived from these measurements show values of roughly 0·2 μsec for intrinsic and *n*-type specimens, for *p*-type samples the lifetime is found to decrease roughly as the electron concentration, at room temperature. These values are shown to be of the same order as the lifetime to be expected from the photon-radiative recombination process (~1 μsec). As the sample temperature is lowered to 100°K, the lifetime in all samples at first rises slightly and then falls sharply to values below 10^{-8} sec. D. G. AVERY

537.311.33 : 535.343

8765. Accurate measurements of absorption in indium antimonide and gallium antimonide. V. ROBERTS AND J. E. QUARRINGTON. *J. Electronics*, **1**, *No.* 2, 152–60 (*Sept.*, 1955).

Absorption spectra for polycrystalline samples of InSb and GaSb are presented, for various temperatures between 4·2°K and room temperature, over the wavelength range 1–24 μ. Analysis of the spectra by the method of Macfarlane and Roberts [Abstr. 4654 (1955)], give values of the activation energy in InSb of 0·165 eV at 290°K, and 0·228 eV at 4·2°K, and in GaSb, 0·695 eV at 290°K and 0·787 eV at 4·2°K. The analysis also suggests that in each case the absorption process is one of indirect transitions between the conduction and valence bands. In the range 100–290°K, the rate of variation of energy gap with temperature in InSb is $-2{\cdot}9\times10^{-4}$ eV/deg C, and in GaSb $-4{\cdot}1\times10^{-4}$ eV/deg C. In both cases the rate falls off markedly at lower temperatures.

D. G. AVERY

537.311.33

8766. The dependence of the current density of a *p–i–n* diode on the thickness of the middle region. A. HERLET. *Z. Phys.*, **141**, *No.* 3, 335–45 (1955) In German.

The field and diffusion currents are investigated and related to the thickness and lifetime of the middle (intrinsic) region. C. A. HOGARTH

537.311.33

8767. Experimental study of the electrical conductivity of complex metal–dielectric layers obtained by evaporation. C. FELDMAN. *Ann. Phys.* [*Paris*] **10**, 435–78 (*May–June*, 1955) In French.

Three types of layer were investigated: (i) layer of metal evaporated on to layer of a salt, (ii) layer of metal and salt from simultaneous evaporation, (iii) layer of a salt evaporated on to a very thin evaporated metal substrate. A similar resistance–temperature law is found for all types of complex layer and the results are explained in terms of potential barriers at the intergranular contacts.

C. A. HOGARTH

537.311.33 : 548.2

8768. Contact rectification as a function of crystal orientation. W. KOSSEL, E. MENZEL AND G. NAUMANN. Note in *Z. Naturforsch.*, **10a**, *No.* 7, 590–2 (1955) In German.

Experiments with cuprous oxide indicate that the

work function and hence the rectification properties depend on the orientation of the Cu_2O.

C. A. HOGARTH

537.311.33 : 621.3.011.4 : 621.314.632

8769. The temperature dependence of the capacity of the copper oxide rectifier. T. Niimi. *J. Phys. Soc. Japan*, **10**, *No.* 6, 444–53 (*June*, 1955).

The capacitance temperature-dependence of the space-charge layer at a metal semiconductor contact is investigated. The variation in the capacitance with temperature has been calculated on the assumption that it should be caused by the temperature variation of the density of free charge carriers in the semiconductor. The results are compared, for example, with the experimental data of the capacitance of copper oxide rectifiers, which are measured by superimposing a small alternating voltage on the d.c. bias voltages, at several temperatures between −160 and +60°C, and are analysed on the assumption that there exist some donor impurities in the bulk cuprous oxide layer in addition to the usual acceptor type. The comparison makes it clear that the equation derived theoretically can successfully explain the following facts: (1) at lower temperatures, the capacitance increases with temperature, reaches a maximum and decreases at higher temperatures; (2) but the temperature at which the maximum is reached is slightly higher than that predicted theoretically; (3) measurements at −110 and −160°C show that the values of the capacitance at these temperatures may be regarded as those affected by the temperature variation in the resistivity of the bulk Cu_2O layer rather than those of the pure barrier capacity; (4) the absolute value for the temperature variation of a barrier capacitance expected from the derived equation is about 250 pF/cm² for copper oxide rectifiers, with −0·5 V d.c. bias voltage applied between 0 and 300°K, and this value agrees fairly well with the experimental results; (5) the variations in capacitance are dependent upon the d.c. bias voltage applied and will be smaller when the bias voltage becomes larger. A.

537.311.33

8770. Rectification properties of metal semiconductor contacts. E. H. Borneman, R. F. Schwarz and J. J. Stickler. *J. appl. Phys.*, **26**, *No.* 8, 1021–9 (*Aug.*, 1955).

Metal semiconductor contacts of a number of different metals were made on *n*- and *p*-type germanium using jet etching and plating techniques. Current voltage curves taken on 12 of these metals on 5 ohm. cm *n*-type germanium showed rectification which follows the diode equation $J = J_0(e^{qV/kT} - 1)$. No correlation was found between the reverse saturation current densities of these diodes and such properties of the metals as work function, electromotive force, etc. For those metal contacts possessing the lowest saturation current densities, calculations indicated the current crossing the contact was to a large percent hole current and that the magnitude of the hole current was controlled primarily by the geometry of the diode. All metals plated on 5 ohm. cm *p*-type germanium produced ohmic contacts of resistivity comparable to the spreading resistance expected for the diode geometry used. For indium diodes, a study of rectification *v.* resistivity indicated that the barrier produced on both *n*- and *p*-type germanium with plated contacts is one to electron flow rather than hole flow. When the assumption of only hole current crossing the barrier was made, it was shown that the I–V curves calculated from the diode theory, for different resistivities of germanium, were in qualitative agreement with the measured curves. Curves of zero voltage conductance *v.* temperature for different resistivities of germanium were also found to be in good agreement with those calculated on the assumption of all-hole current. A.

537.311.4 : 539.62

The contact resistance and mechanical properties of surface films on metals. *See Abstr.* 9198

537.311.62

8771. The theory of skin-effect in a constant magnetic field. M. Ya. Azbel'. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 3, 437–40 (1955) In Russian.

This is in effect a sequel to the paper [Abstr. 8294 (1954)] by the author and M. I. Kaganov which treated the case where a steady magnetic field is perpendicular to the metal surface. From a set of relations analogous to those in the first paper the author works out the impedance of the metal surface and its dependence upon frequency and magnetic field. C. R. S. MANDERS

537.312 : 548.7

8772. Effects produced by metal electrodes in studies of electron bombardment conductivity. J. C. Firmin and C. W. Oatley. *Proc. Phys. Soc. B*, **68**, *Pt* 9, 620–4 (*Sept.*, 1955).

In studies of electron bombardment conductivity, it has commonly been the practice to coat one face of the material under investigation with a metallic film which can act as an electrode. If such a film is sufficiently thin the incident electrons can pass through it without serious loss of energy. The experiments described show that, in some cases, the apparent electron bombardment conductivity is greater with thick films than with thin. They show further that this effect can be ascribed to the generation of X-rays in the film. The bearing of these results on previous measurements of electron bombardment conductivity is discussed. A.

537.312.5

8773. Influence of diffusion lengths and surface recombination on the photovoltaic effect in germanium. H.-U. Harten and W. Schultz. *Z. Phys.*, **141**, *No.* 3, 319–34 (1955) In German.

A study, theoretical and experimental, of the properties of photovoltaic cells consisting of a thin gold layer on the surface of a germanium crystal. The sensitivity of cells using thick germanium crystals is primarily determined by the minority carrier diffusion length. In thin crystal cells the recombination velocity at the free surface of the germanium determines the sensitivity. C. A. HOGARTH

537.312.5

8774. Photo- and semi-conductance of organic crystals. I. Photo-effects in tetracene and anthracene. A. Bree, D. J. Carswell and L. E. Lyons. *J. Chem. Soc.*, **1955**, 1728–33 (*June*).

Tetracene single crystals have been found to display

a photoconductance effect in both the visible and the ultraviolet region. This effect, similar to that in anthracene, is promoted by the presence of air or oxygen, and removed by replacing the air with nitrogen. Thus it is concluded that the photoconductance is a surface phenomenon, in agreement with Lyons's theory to explain the spectral dependence. The photocurrent is in either crystal directly proportional to the applied field and also to the light intensity. Variations of current with time and with changed area of illumination are also reported. Naphthalene and phenanthrene gave no detectable currents under similar conditions to the others, and the theory is advanced that photoconductance varies with ease of aerial oxidation, increasing with ascent of the series naphthalene, anthracene, tetracene. Currents were found to be greater with tetracene than with anthracene. A.

537.312.5

8775. Photo- and semi-conductance of organic crystals. II. Spectral dependence, quantum efficiency, and a relation between semi- and photo-effects in anthracene. D. J. CARSWELL AND L. E. LYONS. *J. Chem. Soc.*, **1955**, 1734–40 (*June*).

Photoconductance in anthracene displays a spectral dependence which reproduces the maxima and minima of the ultraviolet absorption spectrum of the crystal. Such a dependence may be explained by the necessary participation of surface molecules to which absorbed energy must be transferred as excitons. There is a separate threshold of photoconductance for each electronic transition. The position of the transition to a molecular triplet level coincides with the activation energy determined by others for semiconductance. The quantum efficiency of photoconductance depends upon the applied field and is of the order of 10^{-4}. The introduction of 10^{-4} M-tetracene into anthracene increases the photocurrents, especially in the region of the second electronic transition (40 000 cm^{-1}). A.

537.312.5

8776. Infrared quenching and a unified description of photoconductivity phenomena in cadmium sulfide and selenide. R. H. BUBE. *Phys. Rev.*, **99**, *No.* 4, 1105–16 (*Aug.* 15, 1955).

Infrared quenching, superlinearity, temperature dependence, and slow *S*-shape growth of photocurrent in cadmium sulphide and cadmium selenide crystals may all be associated with the filling and emptying of a specific set of defect levels, as indicated by the location of the calculated electron Fermi level. Infrared quenching of photoconductivity occurs only when the Fermi level lies less than 0·8 eV from the conduction band in CdS, or less than 0·6 eV in CdSe; superlinear photoconductivity occurs only when the Fermi level varies between 0·6 and 0·8 eV from the conduction band in CdS, or between 0·3 and 0·6 eV in CdSe; the photosensitivity decreases rapidly as the Fermi level drops further than 0·6 eV from the conduction band in CdS with increasing temperature or further than 0·3 eV in CdSe; a slow, *S*-shaped, growth of photocurrent is observed when the Fermi level rises between 0·8 and 0·6 eV from the conduction band in CdS, or between 0·6 and 0·3 eV in CdSe. Infrared quenching maxima for photon energies of 1·65, 1·35 and 0·89 eV are found for CdS, and 1·20, 1·05 and 0·79 eV for CdSe. The magnitudes of the two lower-energy quenching maxima have a constant ratio to one another (as determined from measurements on CdS), as they vary in different crystals, and are most prominent in photosensitive crystals. A.

537.312.5

8777. Photovoltaic and photoconductive theory applied to InSb. T. S. MOSS. *J. Electronics*, **1**, *No.* 2, 126–33 (*Sept.*, 1955).

Equations are formulated for the distribution of photo-electrons and photo-holes in an intrinsic material. From the results of the photo-voltaic effect it is shown that a value for the ambipolar diffusion length and hence the carrier lifetime may be obtained from the spectral sensitivity curve. Surface recombination is shown to have a marked effect on the magnitude and spectral distribution of the photoconductive response. From these two effects two estimates of the surface recombination velocity are made, both giving values near 5×10^4 cm/sec. A.

537.312.5 : 621.383.4

8778. Portable radiation detectors employing photoconductive cells. J. C. S. RICHARDS. *J. sci. Instrum.*, **32**, *No.* 9, 340–3 (*Sept.*, 1955).

The difficulties inherent in the design of small portable, battery-powered, infrared detectors employing photoconductive cells are discussed, with particular reference to the signal-to-noise ratio of suitable electronic amplifiers, and the method employed to "chop" the radiation. The main novelty is the use of an electromagnetically-maintained vibrating leaf-spring with a shutter suitably mounted at its free end as a radiation chopper. The design and applications of this device are discussed in some detail. A.

537.312.62

8779. Permanent magnetic moments of a superconducting sphere. T. S. TEASDALE. *Phys. Rev.*, **99**, *No.* 4, 1248–51 (*Aug.* 15, 1955).

The magnetic flux retained by a polycrystalline sphere of pure tin has been studied by two experimental methods. It is shown that the amount of flux retained by the superconducting sphere exhibits a reproducible dependence on the temperature at which the transition is allowed to occur. The specimen shows a 99·9% Meissner effect for transitions well below the critical temperature, but near to T_c the percent of residual flux increases several hundred-fold. The residual flux is constant as long as the temperature of the specimen is constant, but the flux is not necessarily conserved when the temperature is perturbed. A.

537.312.62

8780. The penetration depth and high-frequency resistance of superconducting aluminium. T. E. FABER AND A. B. PIPPARD. *Proc. Roy. Soc. A*, **231**, 336–53 (*Sept.* 6, 1955).

Measurements have been made of the surface resistance and reactance of superconducting aluminium, at a frequency of 1 200 Mc/s. From the measurements the magnitude of the penetration depth has been deduced. There is evidence that it may be highly anisotropic, but its average value at 0°K may be taken to be $4 \cdot 9 \times 10^{-6}$ cm, which is close to the

value found previously for tin. This result cannot be explained by the phenomenological theory of London and London (1935) without introducing as an *ad hoc* hypothesis a dimensionless parameter supposed to vary widely between the two metals. It is shown that the alternative non-local theory due to Pippard (1953) is not open to the same objection. The high-frequency resistance R of superconducting aluminium has been found to vary with reduced temperature t in a way similar to that of tin. Reasons are given for believing that the similarity is even more extensive, and that the reduced resistance $r\ (= R/R_n)$ is a universal function of two dimensionless quantities, t and ω/ω_c, for all metals at all frequencies; the characteristic frequency ω_c is given approximately by the quantum condition $\hbar\omega_c = kT_c$. The significance of this result is discussed, and two suggestions are offered as to what modifications to the conventional two-fluid model may be needed in order to explain the exact nature of the function. The surface resistance and reactance have also been measured for aluminium in the normal state; their ratio is in good agreement with the theoretical value. A.

537.312.62

8781. The phase transition in superconductors. IV. Aluminium. T. E. Faber. *Proc. Roy. Soc. A*, **231**, 353–67 (*Sept.* 6, 1955).

For Pt III, see Abstr. 5635 (1954). The interphase surface tension in superconducting aluminium has been measured using techniques applied to tin (see Pt III). It proves to be several times larger than in the latter metal, besides varying rather differently with temperature and showing signs of an interesting dependence on specimen purity. The results are compared with predictions by Pippard (1951, 1953) and Bardeen (1954), and it is shown that the former theory, though less complete, is slightly more successful. On account of its high surface tension aluminium supercools to an unusual extent. In some cases it has been possible to reduce the applied field to 5% of H_c without nucleation occurring. This behaviour appears to be characteristic of the ideal, flawless metal, and it is explained in terms of a simple model based on the idea of coherence. A.

537.312.62 : 539.163

8782. Directional correlation measurements in superconducting metals. H. Albers-Schönberg and E. Heer. *Helv. phys. Acta*, **28**, *No.* 4, 389–94 (1955) In German.

The angular correlation of two successive nuclear radiations following the K-capture of In^{111} has been measured in metallic indium sources above and below the transition temperature. Within the accuracy of the experiment no change in the correlation was found, indicating that the electron distribution is approximately the same in the superconducting and in the normal state. A.

537.312.8/.9 : 538.632

8783. Influence of high pressure on the galvanomagnetic effect in bismuth and its alloys. I. N. E. Alekseevskiĭ and N. B. Brandt. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 379–83 (1955) In Russian.

The effect of a pressure of 1 500 atmospheres on the Hall effect for bismuth and alloys containing a very small percentage of lead has been investigated, together with the change of resistance in the presence of a magnetic field. Both effects are very much reduced by the added pressure at temperatures in the range 4–20° K. The resistance change for the alloy containing a small quantity of lead has been studied as a function of temperature in the range 0–300° K with and without a high pressure. J. M. HOUGH

537.312.8 : 538.63

8784. On the magnetoresistance of Ge single crystals between 10° and 300°K. G. Lautz and W. Ruppel. *Z. Naturforsch.*, **10a**, *No.* 7, 521–6 (1955) In German.

Measurements of transverse magneto-resistance of high purity Ge single crystals at fields up to 24 kilo-oersted provide comprehensive data for comparison with theory. At 11°K a resistance change of $\Delta\rho/\rho_0 = 1\,200\%$ is observed with a slight tendency to saturate with applied field. Hall mobilities at this temperature of 160 000 cm^2 $volt^{-1}$ sec^{-1} were obtained. The effects of magnetic field orientation were investigated and related to anisotropy in the band structure of Ge. The localization of electron tracks at very low temperatures is suggested as a mechanism for the large effects observed. C. A. HOGARTH

537.312.9

8785. Effect of elastic strain upon electrical resistance when cold-work-induced imperfections are present. E. W. Kammer. Letter in *Phys. Rev.*, **99**, *No.* 2, 594 (*July* 15, 1955).

The ratio of the fractional change in resistance to the elastic fractional change in resistance to the elastic fractional change in length of a copper wire has been measured at various temperatures and plastic strains. This ratio varies between 2·5 and 3·5; changes partially anneal out at room temperature, but the results are complex and have not been analysed. W. M. LOMER

537.32 : 536.48

8786. Thermo-electricity at low temperatures. III. The absolute scale of thermo-electric power: a critical discussion of the present scale at low temperatures and preliminary measurements towards its redetermination. W. B. Pearson and I. M. Templeton. *Proc. Roy. Soc. A*, **231**, 534–44 (*Sept.* 20, 1955).

For Pt II, see Abstr. 4557 (1954). In order to compare exactly the present theory of thermoelectric power in metals with the behaviour of the simple alkali metals, particularly sodium, at low temperatures, it is necessary to know the absolute thermoelectric power of one single conductor. There has been only one such determination of an absolute scale of thermoelectric power, and this was derived 23 years ago as the outcome of measurements which had been made primarily for other purposes. As measurements of the thermoelectric force of the alkali metals at low temperatures have recently become available, it is appropriate now to review critically the experimental basis of that scale. In view of new experimental evidence on the behaviour of the thermoelectric power of superconductors just above the transition point which has appeared in the last few years, it appears that a redetermination of the scale is necessary, at least at low temperatures. In this paper the present

absolute scale of thermoelectric force is critically discussed particularly in relation to preliminary measurements towards its redetermination. A.

537.321.01

8787. A mathematical theory of multi-dimensional thermo-electricity with some experimental proofs. A. HIROSE. *J. Inst. Elect. Engrs Japan*, **74**, *No.* 9, 1056–62 (*Sept.*, 1954) In Japanese.

If a bimetallic strip is heated non-uniformly, thermo-currents will flow in the metals. This phenomenon may be termed "multi-dimensional" as opposed to that in a thermocouple. There are two e.m.f.'s causing these thermocurrents, the Thomson e.m.f. and the contact e.m.f. From a mathematical study the current distribution in the metals is uniquely determined. H. G. M. SPRATT

537.323

8788. Measurements of the thermoelectric power of copper oxide [Cu_2O] in the single-phase region. H. SCHILLING. *Ann. Phys.* [*Leipzig*] **16**, *No.* 1–2, 84–92 (1955) In German.

Reports measurements at temperatures between 500 and 1025°c and at oxygen pressures between 100 and 4×10^{-5} mm Hg. The measurements show the oxide to be a defect conductor over the whole range. E. P. WOHLFARTH

ELECTRIC DISCHARGES 537.52

537.521.7

8789. The transfer of metal between electrodes in a high vacuum on application of a high electric field. P. F. BROWNE. Note in *Proc. Phys. Soc. B*, **68**, *Pt* 8, 564–6 (*Aug.*, 1955).

Polonium deposits on either anode or cathode enabled transfer of metal, to a previously inactive electrode, to be studied by exposure to a suitable photographic emulsion subsequent to a discharge. The nature of the traces so obtained is discussed in terms of ion movements, etc., in the discharge. J. D. CRAGGS

537.523.3

8790. Positive point d.c. corona. B. MURPHY. Letter in *Nature* [*London*] **176**, 397–8 (*Aug.* 27, 1955).

Describes measurements of the electrical and optical pulses from d.c. corona (point-plane geometry) in air. The detector band width was such as to give a resolution $\sim10^{-8}$ sec. Oscillograms are shown, with a diagram showing the temporal rate of build up of the luminous discharge. J. D. CRAGGS

537.523.4

8791. Streamer theory and the value of α/p. K. HASEBE AND K. YAMAMOTO. Letter in *Phys. Rev.*, **99**, *No.* 4, 1331 (*Aug.* 15, 1955).

Discusses the importance of accurate measurements of α in assessing the range of applicability of the streamer mechanism of breakdown. Using the new data of Geballe and his colleagues, in which attachment processes are assessed, the agreement between the latter data and the α values required by the streamer theory ($X/p \sim 34 - 46$ V.cm^{-1} mm^{-1}) is seen to be satisfactory. J. D. CRAGGS

537.523.5

8792. High-pressure glow-to-arc transitions with tungsten and copper cathodes. W. L. PRICE, W. A. GAMBLING AND H. EDELS. Letter in *Nature* [*London*] **176**, 28–9 (*July* 2, 1955).

A brief description of the effect of cathode treatment and properties on transitions at atmospheric pressure. It was possible, for example, to maintain a cathode glow régime (with a constricted "arc" column) with a molten copper cathode surface. Hence an arc discharge is not necessarily and inevitably produced in the presence of cathode metal vapour. J. D. CRAGGS

537.523.5 : 537.527.5

8793. The relation between anode [voltage] drop and current strength and arc length in high-temperature arcs. G. BUSZ-PEUCKERT AND W. FINKELNBURG. *Z. Phys.*, **140**, *No.* 5, 540–6 (1955) In German.

Experiments were made with nitrogen and argon arcs carrying currents of 50–500 A. Anode voltage drops were determined essentially by a probe technique. The drops varied from about 17 down to 2 V (nitrogen, 50–200 A) with lower values (~0·5 V) in argon for short arcs (length = 1 mm) at 500 A. J. D. CRAGGS

537.523.5 : 537.525.5 : 537.525.8

8794. Use of narrow holes for producing glow-to-arc transitions. P. L. COPELAND AND B. P. DE LANY. *Science*, **121**, 830–2 (*June* 10, 1955).

Describes experiments with mercury vapour discharges at pressures varying from about 0·001 to 6 mm Hg. Discharges are made to pass, between an anode and a mercury pool cathode, through a small hole and the effect of varying various tube parameters, on the frequency of transition to the arc state, was observed. J. D. CRAGGS

537.525

8795. Note on moving striations. V. D. FARRIS. *J. Electronics*, **1**, *No.* 1, 60–3 (*July*, 1955).

Moving striations in a tube with two anode arms have been shown to be usually symmetrical about the junction with the cathode arm, and not to be propagated past the junction in the opposite direction to the average longitudinal electric field. Some earlier observations on the time required to establish striations have been confirmed, and details noted of the way in which the striations divide. A.

537.525 : 538.561

8796. The appearance of some oscillating discharges. T. K. ALLEN, R. A. BAILEY AND K. G. EMELEUS. *Brit. J. appl. Phys.*, **6**, *No.* 9, 320–2 (*Sept.*, 1955).

An account is given of the appearance of some low voltage, hot cathode discharges generating high-frequency oscillations internally in gas at a pressure of the order of 10^{-3} mm of mercury. The primary electrons are deviated laterally, as well as being accelerated or retarded in their longitudinal motion, at a distance of a few millimetres from the cathode, in or close to a layer of ionized gas which is brighter than the neighbouring plasma. The position of this layer changes discontinuously when a probe is moved through it, giving rise to an apparent abrupt alteration of the electrical properties of the discharge along a line normal to the cathode which is partly spurious.

The layer becomes unstable if large currents are passed, and the tube then also generates oscillations with frequencies below 1 Mc/s. The discharge can be stabilized to higher currents by a longitudinal magnetic field. Two other instances are recorded of a close association of high-frequency and low-frequency oscillations. A.

537.525.3 : 537.525.4

8797. Influence of applied potential on the characteristics of photosensitive non-self-maintained region of a low frequency electric discharge. B. D. KHOSLA. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1373–4 (*July*, 1955).

A brief discussion of the build-up of a Townsend current (avalanche processes) in l.f. electrodeless discharges in iodine vapour. Reference is made to dissociation effects in adsorbed electrode surface layers, and the formation of negative ions in the gaseous part of the discharges. J. D. CRAGGS

537.525.5

8798. Narrowing and spiralling of an arc in rarefied gas at high current strength. V. L. GRANOVSKIĬ AND G. G. TIMOFEEVA. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 378 (1955) In Russian.

Experiments have been carried out in a tube of dia. 70 mm with Hg vapour at 1 μ Hg pressure and with steady currents from 1 to 80 A. A marked contraction in the half-width (diameter where electron density is half that on axis) of the arc is found at the higher currents. Two identical probes were also set up symmetrically with respect to the axis of the arc in such a tube. Effects at the two probes differed markedly and the authors concluded that there were rapid irregular shifts of the contracted arc channel over the cross-section of the tube. A shift was estimated to take place in 10^{-5} sec, so arrangements were made to observe phenomena in times of the order 10^{-6} sec by using discharges from a suitable condenser, all leads being kept short. Photographs are given of arc discharges in argon ($p = 1\,\mu$ Hg, $i_{max} = 450$ A, tube dia. 32 mm) and in Hg vapour at 425 A. In the first the arc is seen as a fine thread occupying only part of the tube diameter. The second shows a spiral thread of arc adjacent to the walls of the tube. A control discharge at $i_{max} = 225$ A shows no appreciable contraction. No break in the arc due to pinch effect has been observed. The authors explain their results, and a large number of analogous observations, as being caused by the magnetic field of the arc discharge; indeed one of them has shown elsewhere that the straight line form of discharge exhibits instability with respect to its own magnetic field. C. R. S. MANDERS

537.525.6 : 538.561 : 535.33

8799. A spectroscopic study of plasma–electron oscillations. T. K. ALLEN. *Proc. Phys. Soc. A*, **68**, *Pt* 8, 696–700 (*Aug.*, 1955).

A demountable discharge tube has been constructed for spectroscopic and probe exploration of low-voltage electron beam discharges through gas at low pressure. Using argon, the probe evidence for presence of electrons with excess energy when plasma–electron oscillations are occurring has been confirmed spectroscopically. The spectroscopic results also confirm the probe evidence for the distribution of oscillations in the discharge, and for the variation with discharge parameters of the position of the main oscillating region. A.

537.525.8

8800. On the reduction in cathode drop of a normal glow discharge due to cathode irradiation. W. KLUGE AND A. SCHULZ. *Z. Phys.*, **142**, *No.* 1, 83–6 (1955) In German.

Discusses the fall in cathode drop when external radiation (in this case light) falls on the cathode of a low-pressure glow discharge. For an argon discharge (0·1 mm Hg pressure) and Ag–KH, K–K cathode the reduction may be about 12 V for i_0 (initial cathode current density) $\simeq 0{\cdot}065 \times 10^{-6}$ A/cm^2. J. D. CRAGGS

537.525.8

8801. Mechanism of potential inversion of the Joshi effect. S. R. MOHANTY. *J. chem. Phys.*, **23**, *No.* 8, 1533–5 (*Aug.*, 1955).

The positive Joshi effect $+\Delta i$ (i.e. the photoincrease of the current i) increases initially with the exciting a.c. potential $V(< V_m$ the "threshold potential") to a maximum at V_m, decreases precipitously and changes sign (to the negative effect $-\Delta i$, i.e. photosuppression of i) at an inversion potential V_i^{I}. Beyond V_i^{I}, $-\Delta i$ first increases rapidly and diminishes slowly thereafter. A second inversion, $-\Delta i \rightarrow +\Delta i$, obtains, in certain systems, at V_i^{II} in the region of high V. Oscillographic studies reveal simultaneous occurrence, at $V > V_m$, of intrinsic $(+\Delta i)$ and intrinsic $(-\Delta i)$; the integrating current indicator shows the balance. The initial $+\Delta i$ at $V < V_m$, and its enhancement with V, result from photoelectron emission from the (momentary) cathode of field-diminished work function. At V_m, consequent to the continuous discharge and an electron residuum from the antecedent half-cycle, largely enhanced emission and space accumulation of negative ions (from attachment of the electrons) lead to incipience of $(-\Delta i)$ due to inhibition of γ and $\eta\theta g$ processes. Electrons able to cross the barrier cause $(+\Delta i)$. The observed co-occurrence of $(+\Delta i)$ and $(-\Delta i)$ follows. Beyond V_m, increase in emission due to field reduction of surface work function enhances space-charge density and therefore $(-\Delta i)$. Observed diminution in $+\Delta i$ follows from the above, and the reduction in the number of photoelectrons able to cross the barrier. At V_i^{I}, $(+\Delta i) = (-\Delta i)$ and therefore, $\pm\Delta i = 0$. Increase of $-\Delta i$ above V_i^{I} also follows from the above considerations. The decrease in attachment probability $P = f(p/F)$, where p is the gas pressure and F the field, leads to subsequent diminution of $(-\Delta i)$ at large V. Increase in the associated $(+\Delta i)$ is a contributory factor, and above V_i^{II} causes the observed positive effect. A.

537.525.8 : 535.416

8802. Glow discharge resonance. A. B. STEWART. *J. Opt. Soc. Amer.*, **45**, *No.* 8, 651–7 (*Aug.*, 1955).

The characteristics of glow discharges in argon and other rare gases excited by an audio-frequency alternating potential and by a direct potential modulated with an audio-frequency signal are described. When the frequency of the alternating potential is of the same order of magnitude as the frequency of the spontaneous oscillations present in these gases excited with

a direct potential, remarkable standing light patterns are observed. In all cases where the discharges are steady enough for detailed measurements striations are found that travel a fraction of the distance from the anode to the cathode in each cycle. At certain positions striations running from the cathode to the anode are also observed. Where the two types of striations meet they are nearly stopped for a time interval of the order of 10^{-4} second. There is electrical and optical evidence that a plasma exists for this time interval and that this plasma emits a continuous radiation. The behaviour and occurrence of the discharges are correlated with a tentatively proposed mechanism. A.

X-RAYS 537.531

537.531 : 535.33

8803. A note on the Al $K\alpha_3\alpha_4$ lines in metal and oxide. B. NORDFORS. *Proc. Phys. Soc. A*, **68**, *Pt* 7, 654–6 (*July*, 1955).

The observations were made with a bent crystal vacuum spectrograph with Geiger counter detector. As well as a large wavelength displacement of the lines there is a change in line shape and intensity in oxide as compared with metal. Typical intensity recordings are given and tables of the line widths and intensity ratios. J. HUGHES

537.531 : 535.33

8804. The *K*-series emission spectrum of neon. H. R. MOORE AND F. C. CHALKIN. *Proc. Phys. Soc. A*, **68**, *Pt* 8, 717–25 (*Aug.*, 1955).

The *K*-spectrum of neon has been examined with a photographically recording bent crystal X-ray spectrometer. The radiation source was an electrodeless discharge tube. The intensity contour of the spectrum was derived leading to a study of the shape of the diagram line $K\alpha_{1,2}$ and an analysis of some satellite structure. Wavelength values are given for the diagram line $K\alpha_{1,2}$ (14·584 7 kX units), the semi-optical diagram line $K\beta_1$ (14·430 kX units) and twenty satellite lines (14·278–14·539 kX units). A.

537.531 : 535.33 : 539.18

8805. *K*-series X-rays from π-mesonic atoms. M. CAMAC, A. D. MCGUIRE, J. B. PLATT AND H. J. SCHULTE. *Phys. Rev.*, **99**, *No.* 3, 897–905 (*Aug.* 1, 1955).

The *K*-series X-rays from the π-mesonic Be, B, C, N and O atoms have been studied. In each case measurements have been made of the $2p$–$1s$ quantum energy, and of the fraction of stopped pions which give rise to *K*-series X-rays (the "*K*-series yield"). The yields are: Be, 18·8 ± 1·7%; B, 13·6 ± 1·5%; C, 9·5 ± 1·0%; N, 4·5 ± 0·5%; O, 3·4 ± 0·4%. The decrease in yield with increasing Z is attributed to nuclear absorption of the pion from the $2p$ state. The $2p$–$1s$ quantum energies are: Be, 43 ± 3·5 keV; B, 68 ± 3·5 keV; C, 92 ± 7·5 keV; N, 132 ± 2·5 keV; O, 163·8 ± 2·7 keV. The expected energy in the case of oxygen, if only electromagnetic interactions are important, is 176·0 keV; the difference is presumably due to a pion–nucleus interaction which is repulsive in the $1s$ state. A.

537.531 : 535.33 : 539.18

8806. *L*-series X-rays from π-mesonic atoms. M. CAMAC, M. L. HALBERT AND J. B. PLATT. *Phys. Rev.*, **99**, *No.* 3, 905–11 (*Aug.* 1, 1955).

The yields of the *L*-series X-ray lines from π-mesonic atoms have been measured for fourteen elements between $Z = 6$ and 26. The total yield rises from 18% at carbon to a maximum of about 70% in the vicinity of aluminium, and then decreases. This decrease is caused primarily by nuclear absorption of pions from the $3d$ state; the $3d \rightarrow 2p$ yield determinations thus measure the nuclear absorption rate from the $3d$ state. The low-Z drop-off is predicted qualitatively by theoretical calculations of the meson cascade scheme. The observed relative intensities of the different *L*-series emission lines are substantially independent of Z in the range $6 \leqslant Z \leqslant 16$. The $3d \rightarrow 2p$ transition energies are consistent with electromagnetically predicted values within the experimental error of 3 to 5% for $Z \leqslant 28$. A.

537.531 : 535.33 : 545.824

8807. X-ray emission spectrography using ion exchange membranes. W. T. GRUBB AND P. D. ZEMANY. Letter in *Nature* [*London*] **176**, 221 (*July* 30, 1955).

An extension of the method of chemical analysis based on X-ray emission spectrography to very low concentrations of metal ions. If the ions are present in solution in concentrations of the order of 1 in 10^9 an ion-exchange membrane is placed in the solution and the metal ions are concentrated in the membrane, which can then be examined in the X-ray spectrograph. The method can also be adapted for analysis of anions. [See H. G. Pfeiffer and P. D. Zemany, *Nature* [*London*] **174**, 397 (1954).] J. IBALL

537.531 : 535.343

8808. The origin of fine structures in X-ray absorption spectra of ionic solutions. A. N. NIGAM. Note in *Proc. Phys. Soc. B*, **68**, *Pt* 7, 472–3 (*July*, 1955).

It is suggested that the fine-structure in the absorption edge of the positive ion is due to energy levels of the photoelectron in the potential well caused by a spherical arrangement of negative ions around the positive ion. A. R. STOKES

537.531 : 535.345.6

8809. Metal foils as filters in the soft X-ray region. D. H. TOMBOULIAN AND D. E. BEDO. *Rev. sci. Instrum.*, **26**, *No.* 8, 747–50 (*Aug.*, 1955).

Describes the use of thin foils of Be, Mg and Al as filters in the 50 to 500 Å spectral region. Mention is made of various procedures for the preparation of plastic backing films. Included are illustrations which show how the metallic filters may be utilized to exclude visible light, to sort out overlapping orders, and to transmit narrow bands of radiation by reducing the intensity of undesirable portions of the spectrum. For each of the metals and for a plastic material (Zapon), plots showing the linear absorption coefficient as a function of wavelength are also given. The absorption curves facilitate the choice of the appropriate filter and its thickness. A.

537.531.08 : 539.18 : 537.542

Detection of mesic X-rays with pressurized proportional counters. *See Abstr.* 8851

CATHODE RAYS . POSITIVE RAYS 537.533/.534

537.533

8810. Non-linear equations of motion in the synchrotron. M. Bell. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. T/M*125, 11 *pp.* (1955).

The Hamiltonian approach to the equations of motion is expounded. The formulation is such that the equations are obtained at once with the azimuthal angle θ rather than the time t as independent variable. The method is applied to obtain the second-order equations of betatron oscillation for an azimuthally homogeneous sector. A.

537.533 : 621.319.339

8811. Externally excited Van de Graaff generator with high belt charge densities. J. Kessler. *Ann. Phys.* [*Leipzig*] **15,** *No.* 7–8, 406–16 (1955) In German.

Discusses the factors which limit the maximum attainable belt surface charge densities. It is shown that spraying charges on both sides of the belt cannot result in an increase in the maximum charge carried. An experimental machine (max. voltage 700 kV), in which the important belt parameters could be conveniently varied, was constructed, and results relating current to belt separation, position of, and voltage applied to the spray combs, are presented. E. A. ASH

537.533 : 621.384.61

8812. On some problems of the operation of microtrons. E. Kisdi-Koszó. *Acta. phys. Hungar.*, **4,** *No.* 4, 377–9 (1955).

New calculations of the energy spread and beam current are made by a graphical method. These give for a 4 MeV accelerator ($V_R = 0{\cdot}5$ MV, $B_R = 1070$ gauss, magnet dia. 30 cm) a spread of $1{\cdot}2\%$ and a current of $10\,\mu$A. The microtron appears capable of giving much smaller spreads than linear accelerators of the same final energy. A. H. W. BECK

537.533.2

8813. The mechanism of high-field electron emission from tarnished metal surfaces. T. J. Lewis. *Proc. Phys. Soc. B,* **68,** *Pt* 8, 504–12 (*Aug.*, 1955).

Recent experiments [e.g. Llewellyn Jones and Morgan, Abstr. 6079 (1953)] have shown that the emission of electrons from smooth cathodes having a thin tarnish film requires the initial deposition of positive ions and that the process then depends on the magnitude of the applied field ($\sim 10^4$ V.cm^{-1}). The mechanism of this emission has hitherto been thought to be one of high-field cold emission through the surface barrier. The nature of this barrier is considered in more detail and it is shown that cold emission is improbable. An alternative theory of field dependent thermal emission is proposed which takes into account the existence of patch fields due to variation in the work function over the surface and uses a more realistic value for the degree of field enhancement near the surface. It is shown that, with this mechanism, the predicted emitting areas can be of more probable dimensions. A.

537.533.2

8814. Interpretation of experiments on electron emission in spark gaps. M. J. Morant. *Proc. Phys. Soc. B,* **68,** *Pt* 8, 513–20 (*Aug.*, 1955).

Recent experiments on electron emission in spark gaps with fields of the order of 10^5 V.cm^{-1} have been interpreted in terms of a Fowler–Nordheim emission process. It is shown that a better explanation is thermionic Schottky emission allowing for surface irregularities, although it is not yet possible to distinguish between the two types of law. Expressions are derived giving relationships between the parameters in the two interpretations. The work function ($\sim 1{\cdot}5$–2 eV) and emitting area (1–10^{-8} cm^2), for agreement with the Schottky effect, should be capable of a much simpler physical explanation than the extremely low values obtained from a Fowler–Nordheim interpretation. A large error can be introduced in the latter case by neglecting thermionic emission. If it is assumed that the emitting surface is heated locally to 500°C, the work functions in the Schottky interpretation are of the order of 4 eV. A.

537.533.2 : 537.312.5

8815. Surface barrier analysis for metals by means of Schottky deviations. D. W. Juenker. *Phys. Rev.*, **99,** *No.* 4, 1155–60 (*Aug.* 15, 1955).

The transmission coefficient for the mirror-image barrier at a metal surface is applied to the case of photoelectric emission. The distribution over which the coefficient is averaged is that given by Fowler for energies normal to the emitter surface, and is altered by the Schottky barrier lowering. The average differs from unity by an amount the major part of which is a periodic function of the accelerating field, giving a periodic deviation from the photoelectric Schottky effect which differs from the thermionic deviation only in amplitude. A refinement in the computation of the unaveraged periodic transmission coefficient brings the theory for thermionic deviations into agreement with that of Miller and Good. The improved form of the thermionic deviation is applied to experimental data to evaluate the complex reflection coefficient μ characterizing the potential form in the immediate vicinity of the surface. The values of $|\mu|$ so obtained for the highly refractory metals are of the order of $0{\cdot}4$, as compared with $0{\cdot}2$ predicted on the basis of the box model. A.

537.533.2 : 537.583

8816. *T–F* emission: experimental measurement of the average electron current density from tungsten. W. P. Dyke, J. P. Barbour, E. E. Martin and J. K. Trolan. *Phys. Rev.*, **99,** *No.* 4, 1192–5 (*Aug.* 15, 1955).

An experimental study of temperature-and-field emission is described in which the average electron current density from the tungsten monocrystal was measured at several fields and temperatures in the ranges $2{\cdot}5\times10^7 < F < 7\times10^7$ V/cm and $300° < T < 2\,000°$K, respectively. The observed agreement between measured and calculated values supports the wave-mechanical theory over larger combined ranges of the variables than previously reported, and further confirms that a high cathode temperature is an arc-initiating factor. A.

537.533.3

8817. A simple presentation of the general theory of systems of revolution in electron optics (relativity and aberrations included). E. Durand. *Rev. Opt.*, **33,** *No.* 12, 617–29 (*Dec.*, 1954) In French.

The author gives a simple demonstration of for-

mulae about all sorts of aberrations in the most general case (electric field, magnetic field, relativity, object and image in the field, etc.). Lagrange equations are invariable for any change in co-ordinates. Computations are much simpler when complex combinations are introduced in the Lagrangian itself. The two Lagrange equations are reduced to only one, for the other is then the conjugate complex equation. Optical analogy and iconal functions are not used. Aberrations are calculated by the classical method which gives a special solution of a differential equation with a second member, when the general solution of the equation without second member is known. A.

537.533.3

8818. Some experiments on a cylindrical electron beam constrained by a magnetic field. J. D. LAWSON. *J. Electronics*, **1**, *No.* 1, 43–52 (*July*, 1955).

A study has been made of the optics of an electron beam with a perveance of 10^{-6} A/V$^{3/2}$ constrained by an axial magnetic field. Measurements of the beam contour for different conditions of entry into the field were made with the aid of a screen which could be moved to intercept the beam. Rough measurements of the radial current distribution, and a measurement of the efficiency of transmission through a drift tube, were also made. Fair agreement with theory was found, although there were significant discrepancies which have not been explained. A.

537.533.3

8819. On the solution of an equation of electron optics. B. MELTZER. *J. Electronics*, **1**, *No.* 1, 53–9 (*July*, 1955).

An analytic solution is given of a class of differential equations, one of which is the ray equation determining the focusing in an X-ray tube. A.

537.533.33

8820. Numerical ray tracing in electron lenses. J. C. E. JENNINGS AND R. G. PRATT. *Proc. Phys. Soc. B*, **68**, *Pt* 8, 526–36 (*Aug.*, 1955).

Liebmann's method of tracing paraxial rays is critically reviewed, corrections being made to the higher terms of his formulae. A new and very accurate method of ray tracing is described, which is a development of that used by Burfoot; the predictor is one used by Goddard and the corrector is the double integration formula on which the method of Störmer is based. Like Goddard's, this method is applicable to marginal as well as to paraxial rays. The results of numerical tests of various methods are compared. The methods of Gautier and Laudet are discussed. The use of the constancy of the Wronskian determinant as a criterion of accuracy of paraxial ray tracing is considered, examples being given of instances in which it is and is not reliable. A.

537.533.335

8821. On the possibility of defining a scalar magnetic potential inside currents, and its application to calculations on magnetic electron lenses. É. DURAND. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 25, 2390–3 (*June* 20, 1955) In French.

For any filament of circulating current, an equivalent magnetic sheet, terminating on the filament but of arbitrary shape, may be defined. By variously choosing the shapes of sheet corresponding to different current filaments, and then adding these for a whole solenoid, a variety of equivalent magnetic representations may be obtained. The respective merits of these, particularly with regard to numerical calculation, are discussed.

A.E.I. RESEARCH LABORATORY

537.533.73

8822. Electron diffraction lines and bands at energies of about 1 MeV. M. PAPOULAR. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 19, 1874–6 (*May* 9, 1955) In French.

A monochromatic beam of electrons of 1 MeV energy, obtained from a linear accelerator, was passed through thin sheets of mica. Kikuchi lines, bands and envelopes of lines were observed when using thick mica, provided that the electron beam was convergent or divergent. Results indicate that, at these energies, inelastic scattering plays a small part in the production of Kikuchi lines, and that the thickness range of mica giving these patterns is in agreement with the predictions of the dynamic theory of electron diffraction. A.E.I. RESEARCH LABORATORY

537.533.74

8823. Effect of electron mass on high energy electron scattering. L. R. B. ELTON. *Proc. Phys. Soc. A*, **68**, *Pt* 8, 741–5 (*Aug.*, 1955).

The effect of the electron mass on the differential cross-section for the scattering of high-energy electrons by atomic nuclei is investigated. It is shown that it is negligible for point nuclei above 5 MeV. The effect on the scattering by extended nuclei is more difficult to estimate, but is almost certainly negligible in the 100–200 MeV region. A.

537.533.74 : 539.152.2

8824. Calculation of the quadrupole moment of the nucleus in the scattering of electrons. V. A. MYAMLIN. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 6, 756–8 (1955) In Russian.

The effect of nuclear quadrupole moment is calculated both for the case of unpolarized and polarized nuclei. G. E. BROWN

537.533.75

8825. Electron energy losses in metallic films of silver and gold. B. GAUTHE. *C.R. Acad. Sci.* [*Paris*] **241**, *No.* 2, 188–90 (*July* 11, 1955) In French.

The electrostatic spectrograph previously described [Abstr. 11110 (1954)] has been improved in several respects to give a dispersion of 2·5 eV per millimetre with a supply of 30 kV. Possible measurement errors are discussed and are put at less than ±1·5 eV. Unsupported films of silver and gold of about 300 Å prepared by evaporation gave almost identical energy losses (apart from a poorly-resolved ray of low volt loss). The experiment is being repeated with beryllium films, preliminary results from which show different volt losses from those for silver and gold.

A.E.I. RESEARCH LABORATORY

537.533.75 : 537.534.75

8826. On the loss of energy by charged particles traversing ferromagnetics. D. IVANENKO AND V. N. TSYTOVICH. *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 291–6 (1955) In Russian.

Investigates the saturation of the energy loss, and

gives an analysis of the separation of this loss into loss through ionization and by Cherenkov radiation.
J. M. RADCLIFFE

537.533.75 : 537.534.75

8827. Energy losses of a charged particle moving in an anisotropic medium. A. G. SITENKO AND M. I. KAGANOV. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 4, 681–3 (1955) In Russian.

By conducting the consecutive calculation of the total loss of a charged particle moving through an anisotropic medium, one does not obtain a divergent expression as obtained previously [Ginzburg, *Zh. éksper. teor. Fiz.*, **10**, 589, 601 (1940); Kolomenskiĭ, Abstr. 2493 (1954)] when the calculation was non-consecutive.
F. LACHMAN

537.533.75 : 537.534.75

8828. Density effect in ionization energy loss of charged particles. J. NEUFELD AND R. H. RITCHIE. *Phys. Rev.*, **99**, *No.* 4, 1125–8 (*Aug.* 15, 1955).

A more rigorous justification is given for the statement made by Aage Bohr that for an incident particle of relativistic velocity, the electrostatic effect of the surrounding electrons is negligible and the main factor in the screening is due to the electromagnetic interactions which limit the impact parameter to a value c/Ω, where $\Omega = (4\pi ne^2/m)^{\frac{1}{2}}$ and n is the electron density in the medium.
A.

537.533.75 : 537.534.75 : 530.162

Straggling of the range of fast particles as a stochastic process. *See Abstr.* 8524

537.533.8

8829. [The] secondary electron emission from the (100) facet of a single crystal of NaCl. L. N. DOBRETSOV AND A. S. TITKOV. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 1, 33–7 (1955) In Russian.

Much of the work on this topic has been done on layers of salt evaporated in vacuum and deposited on metal supports. The shape of the σ against V_p curve and the value of σ_{max} appear to vary with the worker and the particular target. To overcome difficulties due to individual target surface finishes Shul'man *et al.* [*Zh. tekh. Fiz.*, **23**, *No.* 7, 1152–60 (1953)] polished their targets with water, whilst the present authors carried out expts. by the same pulse method using targets polished with GOI (State Optical Institute) paste. Like results were obtained, viz. (i) the curve of σ against V_p depends mainly on the heat treatment of the target shortly before the measurements are taken, (ii) σ_{max} of a thoroughly warmed target $\sim$8, (iii) coefficient of secondary electron emission does not depend on temperature in the range from room temp. to 600°. The paper also discusses expts. carried out by the Shul'man method on the secondary electron emission from a fresh cleavage surface of a crystal. Pulses were of 10 μsec duration, the strength of the primary current pulse was 10^{-8}–10^{-9}A, diameter of electron pencil on target 5 mm. A device was developed for cleaving crystal plates in a vacuum of 10^{-6} mm Hg. In contrast to the expts. above the secondary electron emission from cleavage surfaces shows a clear temperature dependence. Curves are given for σ against V_p at various temperatures also for σ/σ_0 against θ (angle of incidence of primary electron beam) at room temps. for a series of values of V_p. Natural crystals of cooking salt from the Artemovskiĭ Deposits were used, and repeating the expts. with a lab.-grown crystal gave like results.
C. R. S. MANDERS

537.533.8

8830. Theory of secondary electron emission from solids. H. FRÖHLICH. *Proc. Phys. Soc. B*, **68**, *Pt* 9, 657–60 (*Sept.*, 1955).

A formula is derived permitting the calculation of the yield of secondary electrons from the yield of photoelectrons.
A.

537.533.8

8831. The spectrum and angular distribution of the Röntgen bremsstrahlung from a thin anticathode. R. KERSCHER AND H. KULENKAMPFF. *Z. Phys.*, **140**, *No.* 6, 632–41 (1955) In German.

This was measured, for an Al anticathode with a bombarding energy of 34 keV, using a proportional counter. Curves are given of the angular distribution as a function of X-ray energy and of the variation of the spectrum with the angle of emission.
J. HUGHES

537.533.8

8832. The reconciliation of the Sommerfeld theory of Röntgen bremsstrahlung with experimental observations. M. SCHEER AND E. ZEITLER. *Z. Phys.*, **140**, *No.* 6, 642–7 (1955) In German.

It is shown that the experimental results of Kerscher and Kuhlenkampff (preceding abstract) are in agreement with the predictions of the Sommerfeld theory.
J. HUGHES

537.533.8

8833. Anisotropy of bremsstrahlung and pair production in single crystals. F. J. DYSON AND H. ÜBERALL. Letter in *Phys. Rev.*, **99**, *No.* 2, 604–5 (*July* 15, 1955).

Bremsstrahlung can occur coherently from several atoms if the electron beam is incident at a sufficiently small angle to the line joining nearest neighbours in a crystal.
G. E. BROWN

537.533.8 : 537.534.8

8834. Multiple bremsstrahlung. S. N. GUPTA. *Phys. Rev.*, **99**, *No.* 3, 1015–19 (*Aug.* 1, 1955).

The cross-section for the multiple production of photons in bremsstrahlung at high energies is calculated, and it is shown that the probability for multiple bremsstrahlung is quite small compared with that for the ordinary bremsstrahlung even in the very high energy region of cosmic rays. The general problem of multiple photon production is further discussed, and it appears that even at high energies the probability for multiple photon production is appreciable only in the following two cases: (1) an energetic charged particle is deflected through an angle, which is large compared with the ratio of its rest energy and its total energy; (2) an energetic charged particle is annihilated, captured or converted into a neutral particle.
A.

537.534

8835. Large-angle elastic scattering of protons in a synchrotron. J. SEIDEN. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 26, 2519–20 (*June* 27, 1955) In French.

Calculations show that large-angle scattering from residual gases may cause significant loss of protons.
J. J. WILKINS

537.534 : 539.18

8836. Determination of masses of charged particles by scattering on plates and residual range inside a Wilson chamber. M. I. Daĭon. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 3, 453–4 (1955) In Russian.

This was accomplished using the mass formula derived by the application of the multiple scattering theory to Wilson chamber measurements [Abstr. 7355 (1952)]. The experimental set up consisted of a magnetic spectrometer and Wilson chamber containing brass plates. Scattering angles, momenta and residual ranges were measured for particles identified as μ-mesons, and for protons, and gave $M_\mu = 180 m_e \pm 10\%$ and 15% and $M_p = 1\,600 m_e \pm 30\%$ and $1\,800 m_e \pm 30\%$ for thick and thin plates respectively. S. DEDIJER

537.534.3

8837. The application of an inhomogeneous magnetic field to the increase of resolving power of a mass spectrograph. N. E. Alekseevskiĭ, G. P. Prudkovskiĭ, G. I. Kosourov and S. I. Filimonov. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 2, 229–32 (1955) In Russian.

Diagrams and a brief description of the instrument are given and the field variation specified. Typical spectra at masses 4, 20 and 28 are given, the resolving power at mass 28 is approx. 2000. J. HUGHES

537.534.3

8838. Recent research with an experimental mass spectrometer. G. P. Barnard. *J. Electronics*, **1**, *No.* 1, 78–102 (*July*, 1955).

Describes the special features of an experimental mass spectrometer constructed at the National Physical Laboratory. The mass spectrometer (an all-metal instrument) was designed as a precision engineering job for easy dismantling and reassembly. The design was for a 60° sector type, first-order, single focusing, with a 4 in. radius of curvature in the magnetic analyser. Precise angular and linear adjustments of the spectrometer with respect to the magnet could be made during full operation. Measurements were made of the fringing field distribution. The application of ideal field theory to correct for the integrated effect of the fringing flux is, in general, supported by the experimental results obtained with this instrument. This instrument was used mainly for studies of the behaviour of ion sources of the electron bombardment type. Experiments were undertaken with a trochoidal electron beam system. Facilities were available to vary the source details, such as slit widths and electrode spacings, and the relative potentials applied to the different electrodes. The magnetic field in the source region was varied also. In this way, extensive investigations were made of "voltage effects" for various source arrangements. The competing influences of (1) ion beam spread in the plane of the final source slit controlling the transmission efficiency of this slit, and (2) the semi-angle of divergence, α, of the transmitted beam controlling the spherical aberration in refocusing, are clearly exhibited. With a small source magnetic field, a high ionic transmission and a small α cannot be obtained simultaneously with identical potential arrangements in the source. This may be due to lateral velocity components acquired by ions formed in electron beams. The paper concludes with a study of the dependence of mass resolution on the magnitude of the source magnetic field, and a discussion of scanning arrangements necessary for the optimum performance in sector-field instruments. A.

537.534.3

8839. A mass spectrometer for the smallest quantities of gas. F. Smits and J. Zähringer. *Z. angew. Phys.*, **7**, *No.* 7, 313–16 (*July*, 1955) In German.

The special features of the instrument are a high-efficiency ion source and two-channel electronic recording. Typical results are shown for radiogenic and atmospheric argon and estimates of the minimum quantity of gas required given. J. HUGHES

537.534.74

8840. Phase shift analysis of 240-MeV proton–proton scattering. L. Beretta, E. Clementel and C. Villi. Letter in *Phys. Rev.*, **98**, *No.* 5, 1526–7 (*June* 1, 1955).

The analysis is in terms of S and P waves only on the lines and in the notation of Abstr. 6882 (1954) and 6235 (1955). Polarization in double scattering is also considered. W. J. SWIATECKI

537.534.74

8841. Resonances in the elastic scattering of protons. B. B. Kinsey. Letter in *Phys. Rev.*, **99**, *No.* 1, 332–3 (*July* 1, 1955).

The measurements were made by fixing the angle of scattering near the first diffraction minimum and observing the variation of counting rate with beam energy. Most elements gave smooth variations corresponding to displacement of the diffraction minima with beam energy change. Carbon and oxygen however gave sharp peaks as well as the slow variation, for the former the peak was at $22{\cdot}5 \pm 0{\cdot}3$ MeV and half-width $1{\cdot}5$ MeV, while the latter had a peak at $18{\cdot}6 \pm 0{\cdot}3$ MeV, and half-width $1{\cdot}3$ MeV. The interpretation of the resonances is briefly discussed. J. HUGHES

537.534.74

8842. Proton–proton elastic scattering at 950 MeV. P. J. Duke, W. O. Lock, P. V. March, W. M. Gibson, R. McKeague, I. S. Hughes and H. Muirhead. *Phil. Mag.*, **46**, 877–83 (*Aug.*, 1955).

Ilford G5 emulsions exposed to a 950 MeV proton beam from the Birmingham synchrotron, have been searched for proton–proton elastic collisions. Forty-six such events have been found in 950 metres of proton track, equivalent to a cross-section for elastic scattering of $15{\cdot}5 \pm 2{\cdot}5$ mb. The angular distribution of the scattered protons in the centre-of-mass system shows a strong forward peak in agreement with results obtained at Brookhaven by cloud chamber and counter workers. A.

537.534.74

8843. Proton–proton scattering in nuclear emulsions at 432 MeV. S. K. Kao and A. F. Clark. *Phys. Rev.*, **99**, *No.* 3, 895–7 (*Aug.* 1, 1955).

High-energy protons from the unpolarized external beam of the Carnegie Institute of Technology cyclotron were sent through Ilford G5 nuclear emulsions of the normal and 4× gelatin types. The emulsions were area-scanned for Y-shaped stars representing

events of elastic collisions of the incident protons with hydrogen nuclei in the emulsions. These events were identified through angular measurements. With known densities of hydrogen atoms in the emulsions, the differential cross-sections of proton–proton elastic scattering were calculated. The result is consistent with counter measurements. A.

537.534.74

8844. Phenomenological evidence for polarization of 310 MeV protons by elastic scattering in *G* 5 emulsion. J. I. FRIEDMAN. Letter in *Phys. Rev.*, **99**, *No.* 3, 1047–8 (*Aug.* 1, 1955).

A 64% polarized beam of 310 MeV protons was scattered in 600 μ G5 nuclear emulsion. A line scan was made along tracks for elastic scattering events. The scanning efficiency down to 2° is estimated as 100%. Inelastic scattering events in which neutrons are emitted were substantially excluded by energy measurements using grain counting. A rough estimate was made of the number of inelastic events still included by an analysis of 2-prong stars using evaporation theory. Most of the events are due to silver and bromine nuclei and can therefore be lumped together. A graph is drawn of the assymmetry as a function of angle. The average polarization between 3 and 15° is $0{\cdot}44 \pm 0{\cdot}13$, giving good evidence for the high polarization due to elastic scattering. D. J. PROWSE

537.534.74 : 539.153

8845. Classical calculation of differential cross section for scattering from a Coulomb potential with exponential screening. E. EVERHART, G. STONE AND R. J. CARBONE. *Phys. Rev.*, **99**, *No.* 4, 1287–90 (*Aug.* 15, 1955).

The potential energy function considered is $V = (Z_1Z_2e^2/r)\exp(-r/a)$, which approximately represents the potential between two atoms in collision taking into account the screening of the atomic electrons. Here the first factor is the Coulomb potential and the exponential factor contains a screening length a. It is shown first that a classical orbital calculation should give valid results under certain conditions in problems where ions with energies of many thousands of electron volts scatter from atoms. Calculated values of the impact parameters and differential cross-sections are presented for all angles of scattering. These quantities are tabulated for a wide range of parameters corresponding to various degrees of screening. A.

537.534.74 : 778.34

8846. Detection of polarization of beams of fast particles by means of nuclear photo-emulsions. E. L. GRIGOR'EV. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 6, 761 (1955) In Russian.

Plates are placed in a beam of protons of mean energy 570 MeV, scattered out at an angle of 18° from the synchrocyclotron by a beryllium target. Protons scattered in the emulsion of energy >200 MeV are counted, giving a left-right asymmetry of $0{\cdot}11 \pm 0{\cdot}03$. G. E. BROWN

537.534.75

8847. Ranges of protons in medium and heavy elements. B. V. RŸBAKOV. *Zh. éksper. teor. Fiz.*, **28**, *No.* 6, 651–4 (1955) In Russian.

The Bethe–Bloch stopping-power formula is valid only for $E_p \gg (M/m)E_{el}$, where E_{el} is the binding energy of the atomic electrons, and does not give reliable results in some of the region 1–7 MeV for heavy elements. This knowledge is necessary for related work [Abstr. 9069 (1955)]. The range-energy curves are obtained here by measuring the thickness of heavier element equivalent in stopping power to a given thickness of aluminium and assuming the range-energy curve for Al [Abstr. 1232 (1947)]. By interpolation accurate curves are obtained for all Z. G. E. BROWN

537.534.8

8848. Formation of negative hydrogen ions in the passage of protons through thin metal strips. YA. M. FOGEL', B. G. SAFRONOV AND L. I. KRUPNIK. *Zh. éksper. teor. Fiz.*, **28**, *No.* 6, 711–18 (1955) In Russian.

A magnetic analyser distinguishes between negative hydrogen ions (in which the proton has captured two electrons in passage through the foil) and the off-coming proton beam. The ratio of the two beams is measured for protons of energy 11·5–28 keV passing through foils of Be, Al and Cu. It is possible to transform about 10% of the protons passing through thin Be foils into negative ions. G. E. BROWN

DISCHARGE TUBES . COUNTERS 537.54

537.542

8849. The absolute efficiency of counter tube measurements of the activity of radioactive isotopes and for other quantitative work. M. LEISTNER. *Z. Phys.*, **141**, *No.* 4, 463–75 (1955) In German.

A detailed treatment of the factors, etc., limiting the efficiency of counting with particular reference to absolute measurements. The paper stresses work with a 4π solid-angle counter. J. D. CRAGGS

537.542

8850. On the temperature coefficient of Geiger–Müller counters with external cathodes and containing an organic vapour. D. BLANC AND R. VISTE. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 25, 2405–7 (*June* 20, 1955) In French.

Briefly discusses the temperature coefficient of the threshold voltage, etc., of counters in terms of the formation of adsorbed layers on the inner tube wall. Fillings of methylol- and ethanol-argon were used. Data are exhibited graphically. J. D. CRAGGS

537.542 : 537.531.08 : 539.18

8851. The detection of mesic X-rays with pressurized proportional counters using cosmic ray μ-mesons stopped in carbon. D. WEST, R. BATCHELOR AND E. F. BRADLEY. *Proc. Phys. Soc. A*, **68**, *Pt* 9, 801–9 (*Sept.*, 1955).

The advantages of proportional counters over scintillation counters in the study of mesic X-rays from light elements are pointed out. A preliminary investigation is described in which mesic X-rays from carbon are detected with proportional counters. Aluminium counters filled to a pressure of seven atmospheres of xenon were used. A.

537.542 : 539.185.08

8852. Flux measurements with the BF_3 "long counter." W. D. ALLEN. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. NP/R* 1667, 5 *pp.* (1955).

Flux measurements on the Harwell van de Graaff have been made by (1) determining the spectrum of recoils in a proportional counter in which a known volume is filled with hydrogen or methane; (2) determining the response of a BF_3 "long counter" whose efficiency had been checked and calibrated by comparison with Ra–Be and photoneutron sources. Comparison of the two results gave initial discrepancies of about 20%, both in flatness of response and in absolute calibration. It was found that the discrepancies in flatness could probably be ascribed to the drying out of the borax filling which had been used in the outer shield of these original counters. A new long counter, made more closely to McKibben's original recipe (i.e. with outer shield of paraffin and borax) was reasonably flat in the $MnSO_4$ bath tests, although not quite so flat relative to the proportional counter. As regards absolute calibration, the discrepancy of 14% persisted when the long counter was calibrated against the Harwell standard Ra–Be source, even when all of the corrections have been allowed for. When, however, the long counter was calibrated against two radio Th–D_2O sources having widely differing intensities (i.e. in the same energy range as the proportional counter) the agreement was within 2 and 1% respectively, i.e. well within the limits of experimental error. It was also shown that, over a source-detector range of 9 ft the BF_3 counter behaves as a "point detector." The point at which the detector is "centred" varies from 0·3 in. inside the inside face for 20 keV neutrons to 1·9 in. inside the inside face for Ra–Be neutrons. The difference between 0·3 and 1·9 in. is by no means negligible for normal source-detector distances (30–80 in.); in consequence, any statement about "flatness of response" should specify the distance at which the counter has been calibrated. A.

537.542 : 621.317.39 : 621.387.42

8853. On the method employing two sources in parallel for determining the "dead time" of G–M counters. J. M. CAYOLLA CARPINTEIRO. *Técnica* [*Lisbon*] *No.* 249, 275–85 (*Feb.*, 1955) In Portuguese.

The method, a modification of that proposed by Beers, is described and the systematic and accidental errors, both theoretical and instrumental, are discussed. The assumption of a constant resolving-time is criticized: the sensitivity of the electronic recording circuit is limited, the observed activities depend on the solid angle subtended by the counter at a point of the source and this varies with movement of the source. The mathematical theory of the method is developed.

J. A. WILCKEN (R)

537.542 : 539.16.08

8854. A differential ionisation chamber method for continuous flow monitoring of tritium in air in the presence of a significant gamma background and with occasional traces of radon in the sampled air. L. W. D. PITTENDRIGH AND J. E. VOUSDEN. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. HP/R* 1585, 12 *pp.* (1954).

The instrument described consists of a differential ionization chamber designed to operate with a modified Type 1006 monitor, retaining all the facilities of this instrument and including special arrangements to filter the intake air. The air to be sampled for tritium is caused to flow continuously through one-half of the chamber, where the effect of a γ-flux in this half is cancelled out by the differential chamber arrangement. The instrument can operate without significant error in a uniform γ-flux up to at least the maximum permissible level. The dose rate indicated is 0–90 times the maximum permissible daily concentration of tritium in air, and the integrated dose indicator reads up to 12 times the maximum daily dose without manual resetting. Audible alarms are provided for both indicating systems. The presence of radon at 0·03 times the maximum permissible concentration in air (1 M.P.C. $= 3 \times 10^{-10}$ curie/litre) causes no significant error in the readings. The instrument is mains operated and accommodated in the Type 1006 Console. It requires a compressed air supply at 10–15 lb/in.^{2} to actuate the air sampling system. A.

537.542

8855. A portable scintillation apparatus for use in geology. H. SCHNEIDER. *Z. angew. Phys.*, **7**, *No.* 9, 413–16 (1955) In German.

Describes the construction of a battery operated instrument for detecting γ-rays. J. M. HOUGH

537.542

8856. Pulse-height variation in scintillation counters. P. R. BELL, R. C. DAVIS AND W. BERNSTEIN. Letter in *Rev. sci. Instrum.*, **26**, *No.* 7, 726–7 (*July*, 1955).

Increases in counting rate for a given radiation cause an increase in output pulse height of as much as 20% for count changes from tens to thousands per second. The effect is less for low energy pulses. Constant but weak light falling on the multiplier also alters the pulse height. Long-period recovery effects also occur. The effects are assumed to originate at the dynode surfaces. G. F. J. GARLICK

537.542

8857. On some properties of the spark counter for detecting α-particles. E. ANDREESHCHEV AND B. M. ISAEV. *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 335–42 (1955) In Russian.

The counter construction is described and a series of curves given showing how the efficiency and directional properties depend on the counter parameters.

J. HUGHES

537.542

8858. Prospects for the use of impulse multigrid electron-optic tubes to record tracks of ionizing particles in luminescent media. G. A. ASKAR'YAN. *Zh. éksper. teor. Fiz.*, **28**, *No.* 5, 626–7 (1955) In Russian.

A discussion is given of one of the most promising ways of constructing a luminescent counter. The fluorescent track of an ionizing particle is optically projected on the photocathode of an electron-optic tube. An electron image of the projected track passes through several multiplying grids and is accelerated through the anode on to a fluorescent screen. The image produced on the screen can be recorded visually or photographically. Advantages and disadvantages of the arrangement are listed. J. B. SYKES

537.542

8859. Analysis of G-M counter impulses by the method of delayed coincidences. S. P. PURI AND P. S. GILL. *Indian J. Phys.*, **29**, *No.* 2, 95–107 (*Feb.*, 1955).

An interval analyser circuit for studying the origin of spurious pulses in G.M. counter tubes is described. The method of delayed count *v.* delay time is employed in studying their time distribution. An expression for the probability that a real discharge creates an after discharge is derived. The present investigations give (i) an exponential decrease of dead and recovery times with overvoltage, (ii) the life of the petroleum ether filled counter, and (iii) the values of coefficient of secondary emission. The coefficient of secondary emission seems to increase exponentially with overvoltage. It is concluded that the alteration of the optimum gas composition by deterioration with use is the main cause responsible for the high values of this coefficient. The possibility of negative ion formation by molecular dissociation is also suspected. A.

537.542

8860. The resolving time of the Rossi-circuit. E. F. DE HAAN, P. HUIJER AND C. C. JONKER. *Physica*, **21**, *No.* 7, 565–70 (*July*, 1955).

A computation of the resolving time of the Rossi circuit is presented. According to this computation the resolving time is equal to an average of $(\sigma_1 - \sigma_{min})$ over the incoming pulses (σ_1 is the duration of the input pulses and σ_{min} is the duration of the smallest pulse which can pass the bias in the output of the circuit). The best results are obtained when the time-constant $T_2 (= R_a C)$ is large with respect to the duration of the input pulses (R_a is the anode resistance and C the stray capacitance of the anode), and when the quiescent current through the circuit is as small as possible. The authors' experimental results are in agreement with these computations. A.

537.542

8861. Coincidence resolving times. P. HUIJER, E. F. DE HAAN AND C. C. JONKER. *Physica*, **21**, *No.* 7, 571–4 (*July*, 1955).

An analysis is given from a general point of view, and in three limiting cases a result is obtained. In the first case the resolving time is equal to the average duration. In the second case the resolving time is equal to an average of $(\sigma_1 - \sigma_{min})$ over the input pulses (where σ_1 is the duration of the input pulses and σ_{min} is the duration of the smallest pulse which can pass the bias in the output of the circuit). In the third case the resolving time is equal to an average over effective durations of the input pulses. These durations depend essentially on the output bias. A.

537.542

8862. An automatic sample changer for radiometric work. J. RYDBERG. *J. sci. Instrum.*, **32**, *No.* 9, 343–5 (*Sept.*, 1955).

A simple, self-contained, automatic sample changer has been constructed, which can be used together with all common types of radioactivity pulse counters. The construction permits a simple exchange of the detector (for either α-, β- or γ-counting) and allows repeated measurements for a pre-determined time (1 sec to 10 days) or pre-determined count (N to $10^5 N$, where N is the scaling factor) for up to 24 different samples. Data for absorption curves as well as back-scattering curves can be obtained automatically. A.

537.542 : 539.16.08 : 539.167.3

8863. Pulse analysis—a discussion of effects important in the radiochemistry of the heavy elements. K. M. GLOVER. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. C/R*1358, 8 *pp.* (1955).

Discusses some of the principles involved in pulse analysis and of the types of counter suitable for this work, especially with the α-emitters in the heavy-element region. It is intended to show chemists the kind of problems which pulse analysis can help to solve. A.

537.542

8864. Photometric measurement of ionization in cloud chambers. I. BUTTERWORTH. *Phil. Mag.*, **46**, 884–94 (*Aug.*); Erratum, 1152 (*Oct.*, 1955).

It has been found possible to measure the ionization of a cloud chamber track by photometry of the chamber photograph. The method is applicable to tracks, the photographic images of which consist of unresolved drop images. Its application does not interfere with accurate measurement of the magnetic rigidity of the particle causing the track. The use of the method has been investigated by studying tracks in a typical chamber and is illustrated by mass measurements on 3 K-mesons. The relative merits of this photometric method and the drop counting method of measuring ionization are discussed. A.

537.542

8865. The bubble chamber. C. DODD. *Nature* [*London*] **176**, 142–4 (*July* 23, 1955).

Short review of the progresses of this technique. Its possibilities and its main characteristics are briefly discussed, with reference to various types of bubble chambers, both of the "clean" and "dirty" type.

G. MARTELLI

537.542

8866. A gas bubble chamber—a possible recorder of the elementary process of interaction of ionizing radiation with matter. G. A. ASKAR'YAN. *Zh. éksper. teor. Fiz.*, **28**, *No.* 5, 636 (1955) In Russian.

It is suggested that a supersaturated solution of a gas in a liquid might prove suitable for the recording of tracks of ionizing particles, and thus for investigating the elementary processes of interaction of ionizing radiation with matter. Indications are given as to how such a recorder might be made superior to those which operate with superheated liquid.

J. B. SYKES

537.543 : 621.385.16.029.6

8867. On the initial space charge distribution in a cylindrical magnetron diode. R. Q. TWISS. *J. Electronics*, **1**, *No.* 1, 1–7 (*July*, 1955).

Numerical calculations are given for the space charge distribution in a cylindrical magnetron diode, which allow for the thermal emission velocities but neglect electron–electron interaction. In all cases the distribution is of double-stream type even when the ratio of the radius of the space-charge cloud to the cathode radius is less than two. However, the

results obtained are not in agreement with experimental data, described in the abstract following, and a brief outline is given of the lines on which a correct theory might be set up. A.

537.543 : 621.385.16.029.6

8868. The space charge distribution in the pre-oscillation magnetron. L. E. S. MATHIAS. *J. Electronics*, **1**, *No.* 1, 8–24 (*July*, 1955).

A description is given of a molecular beam apparatus which has been used to study the space charge distribution in a smooth anode cylindrical magnetron operating below cutoff. Relative values of the density have been measured as a function of both the radius and the anode voltage in magnetrons with anode to cathode radius ratios of 2·0 and 2·5. The results show that the density falls off gradually from the cathode, smoothly at first, and then in a series of small steps beyond the cloud radius predicted by the stream theories. The space charge has no definite edge. Increasing the anode voltage increases the radius of the cloud and the density at each point in the space charge. None of the quantitative theories predicts a distribution of this form and the implications of this are discussed in the paper by Twiss (preceding abstract). A.

IONIZATION . THERMIONICS 537.56/.58

537.56 : 539.132

8869. The ionization and dissociation of complex molecules by electron impact. J. D. CRAGGS AND C. A. MCDOWELL. *Rep. Progr. Phys.*, **18**, 374–422 (1955).

The report deals with certain experimental and theoretical aspects of collision processes in polyatomic molecular gases. Experimental techniques, dating from about 1932, are reviewed, with more attention given to recent methods. Measurements of critical potentials, cross-sections, and initial kinetic energy of product fragments are described. A survey of the theoretical implications of these data is then given, with reference to the significance of electron-impact ionization potential measurements, for molecules and free radicals, bond dissociation energies for a wide range of molecular types, and certain collision processes involving negative ions. Extensive bibliog. A.

537.56 : 778.34

8870. Dependence of the charge of lithium ions on their velocity. M. I. KUZNETSOV, P. I. LUKIRSKIĬ AND N. A. PERFILOV. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 4, 665–7 (1955) In Russian.

The microphotometric examination of tracks of the fast Li^8 ions obtained in thick-emulsion Ilford C-2 plates has revealed two analogous characteristic discontinuities in the blackening curves. The discontinuities have been attributed to the changes in the ionic charge $Li^{3+} \rightarrow Li^{2+} \rightarrow Li^{+}$. An energy-loss/path curve developed from the blackening/path curve permits the establishment of the relationship between the energy and range for Li ions; the integration constant was taken from the results of Neuendorfer, Inglis and Hanna [Abstr. 4708 (1951)]. The obtained curve tallies accurately with the results of Neuendorfer, Inglis and Hanna, as well as with those of Faraggi [Abstr. 6269 (1951)] and Lonchamp [Abstr. 5530 (1953)]. F. LACHMAN

537.561 : 539.132

8871. Ionization potential of the free HO_2 radical and the $H–O_2$ bond dissociation energy. S. N. FONER AND R. L. HUDSON. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1364–5 (*July*, 1955).

Substantial quantities of HO_2 radicals by reacting H_2O_2 at low pressure with the products of electrical discharges in water vapour and hydrogen peroxide were obtained and investigated in a mass spectrometer. Ionization efficiency curves are shown. The $H–O_2$ bond dissociation energy is found to be 47 ± 2 kcal per mole. W. GOOD

537.562

8872. The specific primary ionization [*I*] by electrons of medium energy in hydrogen, nitrogen, oxygen and argon. K. SOMMERMEYER AND H. DRESEL. *Z. Phys.*, **141**, *No.* 3, 307–18 (1955) In German.

Describes an apparatus designed to measure directly *I* produced by electrons with energies in the range from 1 to 50 keV. The results are compared with those of previous investigations [see Abstr. 6116 (1953)], and it is shown that the ratio of the specific total ionization to *I* is the same for a given gas over a range of electron energies from 4 keV to 1·5 MeV. J. DUTTON

537.562

8873. The theory of the electrical conductivity of plasmas. H. SCHIRMER. *Z. Phys.*, **142**, *No.* 1, 1–13 (1955) In German.

Discusses the integration of the Boltzmann conductivity equation, and considers the effects of electrons, ions and uncharged atoms (or molecules). The electron drift current equation is considered, and there is an examination of collision effects related to the calculation of electron drift speeds, etc. Finally, the treatment is used to estimate a discharge temperature for a h.p. xenon discharge from the electrical loading data. J. D. CRAGGS

537.563

8874. Effect of isotopic substitution on the mass spectra of molecules II. Oxygen and carbon dioxide, experimental. O. A. SCHAEFFER AND H. R. OWEN. *J. chem. Phys.*, **23**, *No.* 7, 1305–9 (*July*, 1955).

For previous part, see Abstr. 2934 (1951). The relative changes in the probability of bond breaking following electron impact have been studied for the molecules $O^{16}O^{16}$ and $O^{16}O^{18}$; $O^{16}C^{12}O^{16}$, $O^{16}O^{13}O^{16}$, and $O^{16}C^{12}O^{18}$. The experimental results were obtained with a 60° mass spectrometer employing a source designed to equalize the collection efficiency of the fragment ions formed. The relative changes were studied systematically as a function of the various ion source voltages. In the case of oxygen the ratio of bond breaking in $O^{16}O^{18}$ divided by that in $O^{16}O^{16}$ is 0·98. The formation of C^+ from $O^{16}C^{13}O^{16}$ is 1·022 times the formation of C^+ from $O^{16}C^{12}O^{16}$ while the formation of C^+ from $O^{16}C^{12}O^{18}$ is 0·997

times the formation of C^+ from $O^{16}C^{12}O^{16}$. The formation of CO^+ from $O^{16}C^{13}O^{16}$ is 0·974 times that from $O^{16}C^{12}O^{16}$ while the relative formation of $C^{12}O^{18+}$ from $O^{16}C^{12}O^{18}$ is 1·03 times and that of $C^{12}O^{16+}$ is 0·97 times the formation of CO^+ from $O^{16}C^{12}O^{16}$. Finally the relative formation of O^{16+} is 1·05 times and that of O^{18+} is 0·98 times the formation of O^+ from $O^{16}C^{12}O^{16}$. The values for $O^{16}C^{13}O^{16}$ are compared to previous values in the literature. A.

537.563

8875. Effect of isotopic substitution on the mass spectra of molecules. III. Carbon dioxide, theoretical interpretation. O. A. SCHAEFFER. *J. chem. Phys.*, **23**, *No.* 7, 1309–13 (*July*, 1955).

The relative changes in pattern for O^{18} and C^{13} substituted carbon dioxide are calculated. The frequencies for the isotopic carbon dioxide molecules and the associated normal co-ordinates are obtained for a harmonic potential function. These are then used as the basis for the ground state vibrational wave-functions. The bond breaking probability integrals are evaluated for various values of the "critical" internuclear separation r_c, and a study is made of the change in predicted bond breaking ratios as a function of r_c. The values of r_c are chosen which give the experimental pattern for $O^{16}C^{12}O^{16}$ and then the relative changes in pattern are calculated for the other molecules and are compared with experimental values. Especially striking is the fact that the calculation faithfully reproduces the change in pattern for the case of a heavier molecule, which is more likely to fragment than a lighter one, as well as for the reverse case. It is concluded that a Franck–Condon type calculation adequately describes the electron impact process in carbon dioxide. A.

537.565

8876. Pulse technique for measurement of the probability of formation and mobility of negative ions. K. B. MCAFEE, JR. *J. chem. Phys.*, **23**, *No.* 8, 1435–40 (*Aug.*, 1955).

A new technique for measurement of the attachment coefficient of electrons to molecules has been devised. The technique involves production of a beam of electrons in an attaching gas. The transient current flowing after the initiation and termination of the electron beam is interpreted as a flow of negative ions produced by electron-molecule collisions. Analysis of the transient current which may last several milliseconds yields a value for the mobility of the negative ions thus formed. The ratio of the magnitude of the electron beam current to the negative ion current yields a direct measure of the attachment coefficient. Preliminary results obtained with SF_6 show a very large attachment coefficient. Values of α/p (the ratio of attachment coefficient to pressure) are considerably larger in SF_6 than those obtained for O_2 in studies elsewhere. As might be expected the mobility of negative ions formed in SF_6 is much lower than that observed for other gases. This is attributed to the very large collision cross-section resulting from (1) the interaction between the negative ion and neutral gas molecules comprising polarization attraction and hard sphere repulsion, and (2) resonance or exchange interaction. A.

537.568

8877. Capture of electrons and ionization by protons in hydrogen. YA. M. FOGEL', L. I. KRUPNIK AND B. G. SAFRONOV. *Zh. éksper. teor. Fiz.*, **28**, *No.* 5, 589–602 (1955) In Russian.

The capture of an electron by the passage of protons, $H_1^+ + H_2 \rightarrow H_1 + H_2^+$ and the ionization $H_1^+ + H_2 \rightarrow H_1^+ + H_2^+ + e$ are measured by collecting the slow particles. The cross-section for capture is considerably larger than the theoretical (Born-approximation) result [Abstr. 2515 (1953)]. By measuring I_-/I_+, the ratio of emerging negative hydrogen ions to the outcoming protons, the cross-section for double ionization is obtained. G. E. BROWN

537.58 : 535.822.9

8878. Thermionic emission microscopy of metals. II. Transformations in plain carbon steels. R. D. HEIDENREICH. *J. appl. Phys.*, **26**, *No.* 7, 879–89 (*July*, 1955).

For Pt I, see Abstr. 7160 (1955). The direct observation of transformations in plain carbon steels at temperatures above about 625°C is demonstrated for both the A_3 and A_1 transformations. It is concluded from emission studies of the decomposition of austenite below the A_3 line that the transformation is of a diffusionless type rather than carbon diffusion controlled. It is shown that carbon is associated with "memory" in the austenite grain structure, the memory improving with increasing carbon content. The emission images also indicate that the growth of a ferrite grain in austenite induces a recrystallization of the surrounding austenite. A model to account for the memory is advanced based on thin sheets of retained austenite in newly transformed ferrite. Studies of a 0·77% carbon steel below the A_1 line illustrate the formation of pearlite. The images suggest that these decompositions take place in two distinct steps. The first is the formation of a metastable crystal which subsequently decomposes by carbon diffusion to the final ferrite–carbide products. Austenite recrystallization about a growing pearlite nodule is demonstrated. A model for the transformation based on a diffusionless type reaction followed by a diffusion decomposition is suggested to explain the emission images. A.

537.583

8879. Cathode sputtering and electron emission. A. GÜNTHERSCHULZE. *Z. Phys.*, **141**, *No.* 3, 346–53 (1955) In German.

A short study of data on the sputtering of various metals in mercury vapour and the noble gases, H_2 and N_2 together with estimates of the secondary emission coefficient γ (electrons per incident ion) is given. C. C. MORGAN

537.583 : 535.377

Thermoemission and thermoluminescence in fluorspar. *See Abstr.* 8646

537.585

8880. The emission of negatively charged carriers by the action of halogen molecules on alkali metal surfaces. W. GEIGER. *Z. Phys.*, **140**, *No.* 6, 608–25 (1955) In German.

Two experimental arrangements are described for investigating this emission in high vacuum. The

largest yield is obtained in the reaction of Cl_2 with Cs, the yield, which is independent of temperature, decreasing from Cs to Li and from Cl_2 to I_2.

W. GOOD

COSMIC RAYS 537.591

537.591.1

8881. On the heavy nuclei in the primary cosmic radiation. H. FAY. *Z. Naturforsch.*, **10a**, *No.* 7, 572–81 (1955) In German.

Describes the results of an investigation on heavy nuclei ($Z > 2$) of the primary cosmic radiation. The measurements were made in 40 stripped emulsions flown over Sardinia ($\lambda \simeq 40°$) at a height of about 27 km for 7 hours. The energy of the nuclei was deduced from their multiple Coulomb scattering, and, if they fragmentated, from the opening angles of their secondary products. For the determination of the charge number Z the measurement of the δ-ray density was sufficient, all particles having energies/nucleon $\geqslant 1{\cdot}3$ GeV. The result is thus independent of possible influences of spurious scattering. The charge spectrum under an average of 32 g/cm^2 of residual material shows that the number of nuclei with $3 \leqslant Z \leqslant 5$ is approximately equal to that of nuclei with $6 \leqslant Z \leqslant 9$. This is in agreement with the charge spectrum found by Dainton. Fowler and Kent, but at variance with the results of Bradt and Peters. The magnitude of the correction to be applied for the scanning loss of Li nuclei is discussed. The correction factor used by Dainton *et al.* appears to be too high. With regard to the influence of the residual material it is shown that the calculated intensity of the Li, Be and B nuclei at the top of the atmosphere will be strongly affected by the uncertainty of the probabilities p_k^i for fragmentation. The fragmentation probabilities found in this work are in good agreement with those obtained by Bradt and Peters and by Gottstein, they are, however, somewhat smaller than those measured by Noon, Kaplon and Ritson. The values of the mean free paths in emulsion can be represented by a formula for the cross-sections given by Peters *et al.* The energy spectrum agrees with that deduced by Kaplon *et al.* from measurements of the latitude effect. It was found that because of spurious scattering cell lengths of at least 4 mm are required in order to measure energies > 4 GeV/nucleon. A spectrum similar to that found by Dainton *et al.* is obtained, if one confines the scattering measurements on cells which are not long enough. The flux of nuclei $Z \geqslant 6$ at the top of the atmosphere is somewhat smaller than measured by other authors at $\lambda = 41°$.

A.

537.591.1

8882. The proton component of cosmic radiation at an altitude of 3200 m over sea level. N. M. KOCHARYAN. *Zh. éksper. teor. Fiz.*, **28**, *No.* 2, 160–70 (1955) In Russian.

Results of continued measurements, partly with the magnetic spectrometer described by the author in *Dokladÿ. Akad. Nauk Armyansk. SSP Erivan.*, **17**, 33 (1953) and partly with a further improved version. The vertical proton intensity expressed as (number of protons) cm^{-2} sec^{-1} sterad^{-1} (BeV/c)$^{-1}$, at 3200 m is found to increase from 1·0 at 0·35 BeV, pass through a maximum of 1·4 around 0·6–0·7 BeV and then decrease to 0·2 at 2·0 BeV. Above 1·2 BeV the decrease corresponds to an inverse power law with an exponent $2{\cdot}65 \pm 0{\cdot}23$. The total intensity for $E > 1$ BeV is deduced to be $0{\cdot}69 \times 10^{-12}$ cm^{-2} sec^{-1}. The deduced mean free path for the absorption of protons in air is discussed in relation to other work. The course of the absorption of protons in Pb was studied by measuring the spectrum (in the range $0{\cdot}5 < E < 2{\cdot}0$ BeV) above and below a 68 g. cm^{-2} layer of Pb. Further, the spectrum of protons generated by neutral particles in a 1 cm layer of Pb was measured for $0{\cdot}45 < E < 2{\cdot}0$ BeV and found to obey an inverse power law with an exponent $2{\cdot}55 \pm 0{\cdot}3$. The number of π-mesons registered leads to a ratio of shower pions to protons from stars in Pb of $\sim 1{\cdot}5$ (cf. ~ 3 for photographic emulsions).

W. J. SWIATECKI

537.591.1

8883. Transition effect and angular distribution of the individual cosmic particles. A. P. ZHDANOV AND P. I. FEDOTOV. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 4, 659–60 (1955) In Russian.

Presents the results of experiments conducted in the Pamirs (alt. 5000 m) in the summer of 1953. Electron-sensitive (up to 90 keV) plates with a 300 μ emulsion layer were exposed for 22 days in a horizontal position. Lead screens of different thickness were used. The total number of particles observed with the 1·4 cm lead absorber is by 30% greater than without any screen. Beginning with the lead thickness of 4·5 cm, the absorption of the component which generates individual heavy charged particles obeys an exponential law. The average free path of this component is 282 ± 15 g/cm^2. The absorption cross-section of the generating component is $\sim \frac{1}{2}$ of the geometric section of the Pb nucleus. The graphs of the angular distribution of the individual cosmic particles show considerable angular anisotropy. See also Abstr. 3434 (1949) and 3246 (1950). F. LACHMAN

537.591.1

8884. The proton component of cosmic rays at aircraft altitudes. K. W. OGILVIE. *Canad. J. Phys.*, **33**, *No.* 9, 555–64 (*Sept.*, 1955).

Experiments with a heavy particle selector installed in an aircraft show that the proton intensity in the energy range 230 to 480 MeV has a variation with height which is exponential, with absorption length 128 ± 10 g/cm^2. The latitude effect between $\lambda = 40°$ N and $\lambda = 56°$ N is in general agreement with that found for fast (up to 5 MeV) neutrons. Some information has been obtained on the variation of the average specific yield for primary energies below 5 BeV.

A.

537.591.1

8885. Further observations of cosmic-ray events in nuclear emulsions exposed below ground. E. P. GEORGE AND J. EVANS. *Proc. Phys. Soc. A*, **68**, *Pt* 9, 829–35 (*Sept.*, 1955).

Earlier work with underground emulsion has been

extended by making observations at greater depths, and by obtaining more data at depths previously employed. The final result for the interaction cross-section of fast μ-mesons with nucleons is $(4{\cdot}6 \pm 0{\cdot}5) \times 10^{-30}\,\mathrm{cm}^2$. The flux of fast π-mesons is certainly less than 0·17% of the flux of fast μ-mesons, and a more probable figure for this ratio is 0·04%. A.

537.591.15

8886. Multiple meson production theories applied to cosmic-ray showers. OSMAN EL-MOFTY AND MOHAMED EL-NADI. *Phys. Rev.*, **99**, *No.* 3, 921–5 (*Aug.* 1, 1955).

The multiple production theories are discussed from the point of view of multiplicity of produced mesons, and of their angular and radial distributions. Assuming that each π^0-meson produces a shower core, these theories are applied to the analysis of previous experiments on the structure of cosmic-ray showers. The analysis favours Fermi's theory with high anisotropy of angular distribution and it was found necessary to assume that only a small fraction of the energy in the original collision goes into the meson production. A.

537.591.3

8887. Absorption analysis of the star-producing component of cosmic rays. IV. The question of the generation of sharp maxima. K.-H. HÖCKER, H. KUHN AND M. RITZI. *Z. Naturforsch.*, **10a**, *No.* 5, 386–94 (1955) In German.

For Pt III, see Abstr. 1971 (1955). From the ranges defined by the maxima of the transition curve for star frequencies and from other experimental data the authors assume that a charged particle is falling on the absorber initially. A two-particle mechanism, including a secondary neutral particle is required to explain star production. Assuming a certain spectral distribution the observed maxima can be calculated, although such particles as are treated theoretically are not, at present, observed. E. W. KELLERMANN

537.591.3

8888. Measurements of the absorption coefficient for nuclearly active particles of high energy. K. P. RŸZHKOVA AND L. I. SARŸCHEVA. *Zh. éksper. teor. Fiz.*, **28**, *No.* 5, 618–19 (1955) In Russian.

Measurements were made at sea level and at an altitude of 3 860 m, using a large-area detector. Lead filters placed above the counters absorbed the electron–photon component and produced electron–nuclear showers under the action of nuclearly active particles. These showers fell on counters separated by lead. There was also a counter one metre away to record extensive showers. The hodoscopic equipment was operated by a shower of at least three particles, at least two of which were of penetrating type. A discussion of the results is given; it is shown that most of the energy of the incident nucleon goes to only one of the secondary particles. J. B. SYKES

537.591.5

8889. Investigation of sidereal time dependence of large showers. A. CITRON AND P. KEHLER. Note in *Z. Naturforsch.*, **10a**, *No.* 6, 499–501 (1955) In German.

This was carried out near Freiburg i.Br. (48°N, 8°E) at 1 230 m by means of a counter arrangement. It seems that the more energetic showers show a sidereal time dependence of 1%. No such dependence is apparent in showers of density of $< 3\,\mathrm{m}^{-2}$, whereas showers of average density of ten times this figure show an amplitude of about 1%; this anisotropy does not seem to increase appreciably with further increase of energy. E. W. KELLERMANN

537.591.8 : 539.18

8890. An analysis of a *K*-meson star. B. DOBOVIŠEK. Letter in *Bull. sci. Cons. Acad. Yougoslavie*, **2**, *No.* 2, 43–4 (*April*, 1955).

A star associated with the capture of a negative *K*-meson has been observed in an Ilford G5 600 μ plate at 23 500 m. The captured *K*-particle has a mass $M_K = (830 \pm 70)m_e$, $(920 \pm 60)m_e$, $(860 \pm 80)m_e$ from photoelectric, gap counting, or gap length determination respectively. The first of the two released particles is probably a π-meson, the third track seems to be that of a proton.

E. W. KELLERMANN

537.591.8 : 539.18

8891. On a super-σ star produced by the capture of a K_σ meson. TSAI-CHÜ. *C.R. Acad. Sci.* [*Paris*] **241**, *No.* 3, 294–6 (*July* 18, 1955) In French.

A star with six branches has been observed following the capture of a K_σ-meson. None of the branches are π-mesons or hyperons. The mass of the incident heavy negative meson is shown to be within 10% of the mass of a τ-meson. A. J. EGGINTON

MAGNETISM 538

538.082.743

8892. A new method for investigating the domain structure of ferromagnetics. J. KACZÉR. *Czech. J. Phys.*, **5**, *No.* 2, 239–44 (*April*, 1955).

The method uses a Permalloy probe in the form of a very thin strip which is made to vibrate near the surface of the specimen and is surrounded by a secondary coil. The magnetic field on the surface produces a flux in the probe whose time derivative gives the voltage induced in the coil. Results obtained by the method on an iron–silicon crystal were compared with results obtained by the powder pattern method. E. P. WOHLFARTH

538.083 : 537.226.1.08

Measurements on ferromagnetic materials at frequencies around 10^4 Mc/s. *See Abstr.* 8729

538.114

8893. Dipolar sums in the primitive cubic lattices. M. H. COHEN AND F. KEFFER. *Phys. Rev.*, **99**, *No.* 4, 1128–34 (*Aug.* 15, 1955).

Dipole-wave sums, important in many magnetic and electric problems involving dipole–dipole interactions, are defined, and numerical values are given at sets of independent points in k-space equivalent to a 512-fold sampling of the first Brillouin zone of each of the three primitive cubic lattices. Strong size, shape and position dependence of these sums is shown to occur in a pathological region about the origin in k-space. The dipole-wave sums are shown

to be related to dipole-field factors at points within the unit cell. The dipolar anisotropy energy in the anti-ferromagnet MnO is discussed as an illustration of the use of dipole-wave sums. A.

538.114

8894. Dipolar ferromagnetism at 0°K. M. H. COHEN AND F. KEFFER. *Phys. Rev.*, **99**, *No.* 4, 1135–40 (*Aug.* 15, 1955).

A critical examination of the Holstein–Primakoff spin-wave technique has yielded explicit criteria for the stability of ferromagnetic arrays. These criteria have been applied to point dipoles on the three primitive cubic lattices for the shape most favourable to ferromagnetism, that of a long, thin sample. The results are: (1) dipolar ferromagnetism cannot occur in the simple cubic lattice; (2) the ferromagnetic state can be the lowest, or at least a metastable, state on the face-centred cubic and body-centred cubic lattices. The zero-point energies of ferromagnetic states are calculated for the ⟨100⟩, ⟨011⟩ and ⟨111⟩, directions, yielding two anisotropy constants, K_1 and K_2, for each lattice. The Holstein–Primakoff Hamiltonian is shown not to be diagonal for spin waves in the pathological region, i.e. of wavelengths comparable to the dimensions of the specimens. The properties of this region are shown to be unimportant in energy considerations but may effect stability. They are of great importance in effects such as ferromagnetic resonance which involve long-wavelength spin waves. A.

538.114

8895. The Néel theory of ferrimagnetism. J. S. SMART. *Amer. J. Phys.*, **23**, *No.* 6, 356–70 (*Sept.*, 1955).

The Néel theory of ferrimagnetism is a molecular-field theory of magnetic ordering in systems which contain non-equivalent substructures of magnetic ions. The two principal results of the theory are: (*a*) the curve of reciprocal susceptibility *v.* temperature above the Curie temperature is an hyperbola, and (*b*) the curve of spontaneous magnetization *v.* temperature below the Curie temperature may have any one of a number of unusual forms. The exact form depends on the distribution of magnetic ions between the substructures and on the relative values of the molecular field coefficients. The agreement between the predictions of the Néel theory and some experimental observations on ferrites is discussed briefly. A.

538.114 : 538.221 : 621.395.625.3

8896. Remanence curve of single-domain ferromagnetic particles. Application to the coatings of sound-recording tapes. E. P. WOHLFARTH. *Research* Correspondence, **8**, *No.* 8, S 42–S 44 (*Aug.*, 1955).

Gives results of calculations of a curve relating the reduced remanent magnetization I_R/I_0 with a reduced field for an assembly of randomly orientated particles having uniaxial anisotropy. Application is made to γ–Fe_2O_3 powders used as tape coatings, using the data given by Osmond [Abstr. 1989 (1955)].

E. P. WOHLFARTH

538.114 : 539.11

Electronic energy bands in iron. *See Abstr.* 8951

538.22 : 535.371

Magnetism on optical excitation of manganese-activated zinc sulphide phosphors. *See Abstr.* 8636

538.221

8897. Ferromagnetism in noble metal alloys containing manganese. F. A. OTTER, JR, P. J. FLANDERS AND E. KLOKHOLM. Letter in *Phys. Rev.*, **99**, *No.* 2, 599–600 (*July* 15, 1955).

Reports values of the Curie temperatures and saturation magnetizations of the alloys Au + 18·64% Mn, Au + 13·01% Mn and Ag + 14·58% Mn. The first of these possesses a paramagnetic component of magnetization in high fields. Resistivity, temperature curves for these and some other related alloys are also shown. E. P. WOHLFARTH

538.221

8898. Paramagnetic study of rare earth ferrites. R. BENOIT. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 25, 2389–90 (*June* 20, 1955) In French.

Gives results of susceptibility measurements for the following substances above their Curie points: Fe_2O_3 . M_2O_3, where M = La, Gd, Dy, Er.

E. P. WOHLFARTH

538.221

8899. Figure of merit for microwave ferrites at low and high frequencies. B. LAX. Letter in *J. appl. Phys.*, **26**, *No.* 7, 919 (*July*, 1955).

The figure of merit F is defined as the ratio of the Faraday rotation to the attenuation and is shown to equal ωT, where ω is the frequency and T the Bloch–Bloembergen relaxation time constant. Typical values of F are estimated. E. P. WOHLFARTH

538.221

8900. Dependence of the coercive force on the density of some iron oxide powders. A. H. MORRISH AND S. P. YU. *J. appl. Phys.*, **26**, *No.* 8, 1049–56 (*Aug.*, 1955).

An experimental investigation has been made of the dependence of the coercive force on the density of some magnetite and γ-ferric oxide powders consisting of different sized and shaped particles. Various aspects of the data are discussed. In particular, an interpretation based on a calculation of the critical single domain size of iron oxide particles with a prolate spheroidal shape is consistent with the experimental results. A.

538.221

8901. Frequency dependence of magnetic resonance in α–Fe_2O_3. H. KUMAGAI, H. ABE, K. ÔNO, I. HAYASHI, J. SHIMADA AND K. IWANAGA. *Phys. Rev.*, 99, *No.* 4, 1116–18 (*Aug.* 15, 1955).

Magnetic resonance absorption in single crystals of natural α–Fe_2O_3 was examined in the wavelength range from 5·4 mm to 6·2 cm. Resonance fields H_r observed in the basal plane do not give a quadratic relation with the normal resonance field H_0 as predicted by the usual Kittel formula, but rather the following linear relationship: $h\nu/g\beta = H_0 = H_r + H_A$, where H_A is $4{\cdot}2_5K$ oe and g is $2{\cdot}5_4$. A.

538.221

8902. Ferromagnetic resonance in two nickel–iron ferrites. W. A. YAGER, J. K. GALT AND F. R. MERRITT. *Phys. Rev.*, **99**, *No.* 4, 1203–10 (*Aug.* 15, 1955).

Ferromagnetic resonance data are presented as a

function of temperature from 4·2 to 380°K in $(NiO)_{0.95}(FeO)_{0.05}Fe_2O_3$ and $(NiO)_{0.75}(FeO)_{0.25}Fe_2O_3$. When the effects of eddy currents are corrected for, most of the energy dissipation $(NiO)_{0.75}(FeO)_{0.25}Fe_2O_3$ as measured by the resonance line width is shown to be due to a relaxation mechanism associated with the presence of divalent iron. The line width shows a maximum at 160°K at the frequency of measurement (24 000 Mc/s). A thermodynamical analysis of the loss mechanism is presented which assumes that a torque associated with part of the free energy relaxes. This correlates the line width quite satisfactorily with the temperature dependence observed in the magneto-crystalline anisotropy and the spectroscopic splitting (g) factor. A.

538.221

8903. Effect of nitrides on the coercive force of iron. J. KERR AND C. WERT. *J. appl. Phys.*, **26**, *No.* 9, 1147–52 (*Sept.*, 1955).

The effect of plates of nitrides on the coercive force of iron has been determined. A pronounced particle size effect was observed. The maximum effect on the coercive force was produced by particles whose largest dimension was of the order of the domain wall thickness, δ. For particles much larger than δ, an expression given by Néel for the effect of inclusions is found to be valid. The results of this study are in good agreement with earlier results reported for the effect of carbides on the coercive force of iron. A.

538.221 : 537.311.32

Relation of magnetic structure to electrical conductivity in NiO and related compounds. *See Abstr.* 8744

538.221 : 538.63

8904. The problem of the galvanomagnetic effects in ferromagnetics. K. M. KOCH. Note in *Z. Naturforsch.*, **10a**, *No.* 6, 496–8 (1955) In German.

538.221 : 538.632

8905. Ferromagnetic Hall coefficient of nickel alloys. A. I. SCHINDLER AND E. I. SALKOVITZ. *Phys. Rev.*, **99**, *No.* 4, 1251–2 (*Aug.* 15, 1955).

Published Hall coefficient data for binary Ni alloys have been examined in light of the Karplus–Luttinger theory of the ferromagnetic Hall effect. This theory indicates that the extraordinary Hall coefficient is related to the square of the electrical resistivity, $R_1 = A\rho^2$. Neither the exponent nor the coefficient of ρ varies as additions of up to 30 atomic per cent Cu are made to pure Ni, and as the temperature is varied from 20 to 290°K. On the other hand, small additions of either Al, Si or Sn to Ni cause a significant variation in A, but appear to leave the exponent of ρ unaltered. A tentative explanation is offered for the difference in behaviour. A.

538.221 : 538.652

8906. Magnetostriction and permeability of magnetite and cobalt-substituted magnetite. L. R. BICKFORD, JR, J. PAPPIS AND J. L. STULL. *Phys. Rev.*, **99**, *No.* 4, 1210–14 (*Aug.* 15, 1955).

The principal magnetostriction constants of magnetite were determined over the temperature range from 120 to 300°K by the strain-gauge technique. Since λ_{111} and λ_{100} are different in sign and practically constant over this entire range ($\lambda_{111} \simeq +80\times10^{-6}$; $\lambda_{100} \simeq -20\times10^{-6}$) the change in direction of easy magnetization which occurs at 130°K is manifested by a change in structure of λ $v.$ H curves in a polycrystalline sample. The substitution of small amounts of cobalt for divalent iron in polycrystalline magnetite causes a marked shift upwards in the temperature of the maximum in initial permeability, which in the case of magnetite occurs at 130°K. The temperature shift is practically linear with respect to cobalt ferrite content, the rate being ~140 deg c/mole per cent. Magnetostriction $v.$ magnetic field curves for these specimens indicate that the shifted permeability peak is still associated with a change in direction of easy magnetization. The predicted anisotropy of cobalt ferrite, obtained by extrapolation of these results, is in reasonable agreement with the values measured directly by other investigators. A.

538.221 : 548.736.4

A review of the structure and some magnetic properties of ferrites. *See Abstr.* 9275

538.221 : 548.736.4

Constitution and magnetic properties of ferromagnetic titanomagnetites and ilmenites. *See Abstr.* 9276

538.222

8907. Paramagnetic resonance. II. K. D. BOWERS AND J. OWEN. *Rep. Progr. Phys.*, **18**, 304–73 (1955).

In this report, which is complementary to that of Bleaney and Stevens in *Reports on Progress in Physics*, Volume XVI [Abstr. 8566 (1953)], paramagnetic resonance data are collected together for crystalline solids containing ions of the transition groups, and those parts of the theory necessary for an understanding of the results are presented in a fairly simple way. After a brief introduction, the magnetic properties of various types of compounds are considered, and a simple discussion is given of the spin Hamiltonian which is used to describe the lowest energy levels. Some details are also given of the structures of the ten crystal types which are most commonly used, and of the relation between the structure and the resonance spectrum of a single crystal. Finally, the resonance data which are available for ions of the 3d, 4d, 5d, 4f and 5f transition groups are tabulated. These data are expressed as values of the parameters in the appropriate spin Hamiltonian, and, where applicable, formulae are given for (1) energy levels, (2) susceptibility, (3) specific heat tail CT^2/R, in terms of these parameters. Extensive bibliography. A.

538.222

8908. On the spin paramagnetism of a free electron gas. II. B. DONOVAN, A. B. LIDIARD AND N. H. MARCH. *Proc. Phys. Soc. A*, **68**, *Pt* 7, 644–7 (*July*, 1955).

For Pt I, see Abstr. 1461 (1954). Describes the application of a more accurate distribution function in the variational method to the problem of calculating the susceptibility as a function of temperature. An anomaly previously found at intermediate temperatures is thereby removed. E. P. WOHLFARTH

538.222

8909. Magnetic susceptibility of cupric oxide CuO. H. Bizette and B. Tsaï. *C.R. Acad. Sci.* [*Paris*] **241,** *No.* 2, 182–4 (*July* 11, 1955) In French.

Reports results of susceptibility measurements between 4 and 360°K. A broad minimum occurs near 100°K. E. P. WOHLFARTH

538.222

8910. Magnetic properties of titanium sesquioxide between 300° and 1700°K. M. Foëx and J. Wucher. *C.R. Acad. Sci.* [*Paris*] **241,** *No.* 2, 184–6 (*July* 11, 1955) In French.

Reports results of susceptibility measurements. A rapid increase in susceptibility takes place at 473°K, followed at higher temperatures by a more gradual increase. See also following abstract.

E. P. WOHLFARTH

538.222

8911. Attempt at interpreting the high temperature magnetic properties of the rhombohedral sesquioxides of titanium, vanadium, chromium and iron (Ti_2O_3, V_2O_3, Cr_2O_3, Fe_2O_3). J. Wucher. *C.R. Acad. Sci.*, [*Paris*] **241,** *No.* 3, 288–90 (*July* 18, 1955) In French.

The experimental susceptibility data are interpreted by assuming antiparallel spin coupling for nearest neighbour ions, the interactive energies per ion pair, deduced from the data, being respectively 1600, 400, 280, 280 (in units k). E. P. WOHLFARTH

538.222

8912. Magnetic transformation of cerium at high temperatures. Influence of magnesium impurities. F. Gaume-Mahn. *C.R. Acad. Sci.* [*Paris*] **241,** *No.* 3, 286–8 (*July* 18, 1955) In French.

Reports results of susceptibility measurements for pure Ce between 290 and 1030°K. A fairly rapid decrease of the susceptibility takes place near 960°K on heating, with pronounced temperature hysteresis on cooling below this temperature. The transformation point is lowered by the addition of small amounts (1 to 2%) of Mg. E. P. WOHLFARTH

538.222

8913. The structure and magnetic properties of the alloy Mn_3AlC. R. G. Butters and H. P. Myers. *Phil. Mag.*, **46,** 895–902 (*Aug.*, 1955).

An alloy of composition close to Mn_3AlC was prepared by induction melting. In the as-cast state the alloy was feebly magnetic at room temperature and the magnetic property was retained after homogenization at 1000°C. This alloy was composed of a single phase possessing an ordered face-centred cubic structure with lattice parameter 3·869 Å. The ordered structure is similar to that found in the alloy Mn_3ZnC, the properties of which have been described elsewhere. The alloy Mn_3AlC, is strongly magnetic at low temperatures having a saturation moment at 0°K of 99·6 ergs.g.$^{-1}$oersted^{-1} equivalent to a Bohr magneton number 1·20 per Mn atom, the Curie temperature being 15°C. The paramagnetic susceptibility measured over the temperature range 65–800°C, was found to vary with temperature in a manner different from a normal ferromagnetic material, the $1/\chi$–T graph possessing pronounced curvature concave to the temperature axis. A.

538.222

8914. Paramagnetic resonance absorption in glass. R. H. Sands. *Phys. Rev.*, **99,** *No.* 4, 1222–6 (*Aug.* 15, 1955).

Paramagnetic resonance absorptions occurring with spectroscopic splitting factors of 4 and 6 were noted in all glass samples studied. These were apparently anisotropic g-values for a specific impurity and the peaks recorded are interpreted as being the result of a distribution of Stark fields over all directions in the glass. Resonances were also recorded having g-values near 2. Nearly all of these showed hyperfine structures characteristic of the known paramagnetic additions in the glasses. The absorption line observed for cupric ions in lattice modifying positions in a soda-lime-silica base glass has been quantitatively explained and the parameters compared favourably with those resulting for copper in the Tutton salts. A.

538.222 : 539.185

8915. Energy distribution of neutrons scattered by paramagnetic substances. B. N. Bröckhouse. Letter in *Phys. Rev.*, **99,** *No.* 2, 601–3 (*July* 15, 1955).

Gives curves showing the energy distribution of neutrons of wavelength 1·29 Å after scattering by anhydrous specimens of $MnSO_4$ and Mn_2O_3.

E. P. WOHLFARTH

538.224

8916. The diamagnetic susceptibility of aromatic compounds. J. Schuyer. Note in *Naturwissenschaften*, **42,** *No.* 13, 388 (1955) In German.

For this an additive formula is given by means of which the number of aromatic rings in complicated molecules, as are present in hard coal, may be estimated. W. GOOD

538.224

8917. Magnetic susceptibility and free energy of graphite bromide. G. R. Henning and J. D. McClelland. *J. chem. Phys.*, **23,** *No.* 8, 1431–5 (*Aug.*, 1955).

The magnetic susceptibility of graphite bromide residue compounds has been measured by a Faraday method. The addition of bromine decreased the diamagnetism of graphite. Fair agreement was obtained between the measured diamagnetism and values calculated by assuming an undistorted graphite band structure depleted in electrons due to the dissociation and ionization of two out of eleven bromine molecules. It has also been shown that the transfer of electrons from the graphite bands to bromine can account for the observed pressure dependence of the graphite bromine equilibrium. A.

538.224 : 538.639

8918. Pressure dependence of de Haas–van Alphen parameters in bismuth. W. C. Overton, Jr and T. G. Berlincourt. *Phys. Rev.*, **99,** *No.* 4, 1165–9 (*Aug.* 15, 1955).

The Hall coefficient, A, of a bismuth single crystal has been measured at 4·2°K, in magnetic fields up to 12 kilogauss, and under liquid helium pressures up to 120 atm. The period (β/E_0) of the oscillations in reciprocal field, the phase and the monotonic part of the magnetic field dependence of A were found to depend on the pressure with small, but nevertheless

easily measurable, pressure coefficients. Only the single-period term observable in bismuth when the magnetic field is parallel to the trigonal axis was studied. A.

538.23

8919. The theory of the hysteresis losses in a rotating magnetic field. M. KORNETZKI AND I. LUCAS. *Z. Phys.*, **142**, *No.* 1, 70–82 (1955) In German.

A discussion of the ratio of the hysteresis loss in a rotating field to that in an alternating field of the same amplitude. For small values of the field strength the ratio is calculated to be equal to 2·36 for an isotropic polycrystalline substance, both for 90 and 180° domain boundaries, in good agreement with observation. In the limit of large fields the ratio is shown to tend to zero. E. P. WOHLFARTH

538.23

8920. New method for determining the hysteresis loop of a ferromagnetic body subjected to an alternating magnetic field. II. Experimental. J. GARCÍA SANTESMASES AND M. ALIQUE PAGE. *An. Real Soc. Españ. Fis. Quím.*, **51(A)**, *No.* 5–6, 107–14 (*May–June*, 1955) In Spanish.

For Pt I, see Abstr. 7193 (1955). Presents and discusses experimental results of (*a*) variation of zero error with heater current in the pentode valves, and a simple compensation arrangement, (*b*) calibration of the apparatus, and (*c*) some measurements on a silicon iron specimen. The overall accuracy is believed to be within 1·5%. F. F. ROBERTS

538.24 : 538.66

8921. The direct separation of the reversible and irreversible components of the magnetothermal effect. L. F. BATES AND N. P. R. SHERRY. *Proc. Phys. Soc. B*, **68**, *Pt* 9, 642–8 (*Sept.*, 1955).

A new method is described for separating reversible and irreversible components of the magnetothermal effect by carrying out small, "backward" increments in magnetization at given points on the hysteresis cycle. With the sensitivity of the existing apparatus this method is of limited application, but with increased sensitivity it could be applied generally. Results for the reversible and irreversible heat changes measured with a cobalt specimen, confirm that if reversible thermal effects alone are measured, the b'' coefficient, as defined in the Stoner and Rhodes theory, remains constant over the hysteresis cycle. A.

538.242

8922. Gyromagnetic ratio of iron at low magnetic intensities. G. G. SCOTT. *Phys. Rev.*, **99**, *No.* 4, 1241–4 (*Aug.* 15, 1955).

It is shown that the measured value for the gyromagnetic ratio of pure iron as determined by a direct magneto-mechanical method, undergoes a change for low values of the induced magnetic intensity. The effective value of this ratio extrapolated to zero intensity, checks the value which is theoretically expected from a consideration of recent ferromagnetic resonance experiments. For higher values of the induced magnetic intensity, the gyromagnetic ratio approaches a constant value which checks the value obtained in previous investigations based upon the Einstein–de Haas effect. A.

538.27 : 538.632

8923. Hall effect in Permalloys. S. FONER. *Phys. Rev.*, **99**, *No.* 4, 1079–81 (*Aug.* 15, 1955).

Measurements of the Hall effect for two Permalloys of approximately 25 and 55% Fe in Ni are reported and compared with recent results for some Co–Ni and Fe–Ni alloys. Qualitative aspects concerning the band structure of these Fe–Ni alloys are briefly discussed. A.

ELECTROMAGNETISM . ELECTRODYNAMICS
538.3/.5

538.3 : 530.12

8924. On the singular electromagnetic field. L. MARIOT. *C.R. Acad. Sci.* [*Paris*] **241**, *No.* 2, 175–6 (*July* 11, 1955) In French.

See Abstr. 9395 (1954). The Cauchy problem is considered. R. A. NEWING

538.3 : 530.145

The representation of the electromagnetic field by retarded potentials. *See Abstr.* 8491

538.3 : 537.213

8925. The inversion problem in generalized electrodynamics. H. KOPPE. *Z. Naturforsch.*, **10a**, *No.* 7, 505–8 (1955) In German.

An expression for the potential due to a charged particle in Bopp's theory reduces to $U(r^2) = \int_{-\infty}^{+\infty} f(c^2t^2 - r^2)dt$ in the static case, and the problem considered is to find f given U. It is shown that there is a unique solution in the case of retarded potentials (strict causality) provided U satisfies certain restrictive conditions. R. A. NEWING

538.55

8926. Nature of the primitive system in Kron's theory. B. HOFFMANN. *Amer. J. Phys.*, **23**, *No.* 6, 341–55 (*Sept.*, 1955).

The idea of a primitive system in Kron's theory is shown to involve two distinct concepts and to be not well defined. An attempt is made to give a sharper definition. The discussion is confined to electrical networks. The anomaly is stressed that though Kron's primitive network and the given network are physically different, the transformation laws imply that their instantaneous power inputs are equal. Ways proposed by various authors of avoiding this anomaly are briefly discussed. Some ignore the primitive network; others make the primitive network physically equivalent to the given network, either by changing the primitive network or by changing the given network. Since this does not accord with the method by which Kron forms his primitive network, the view is put forward that the primitive network is physically different from the given network. A new network, the "connected primitive network," is introduced which, among other things, clarifies the physical significance of a singular C-transformation. The given network and primitive network are considered to stand for infinite families of networks; the singular C-transformation then selects from the family of

primitive networks a subfamily that coincides with the family of given networks. A.

ELECTROMAGNETIC WAVES AND OSCILLATORS 538.56

538.56

8927. Hertzian electromagnetic potentials and associated gauge transformations. A. NISBET. *Proc. Roy. Soc. A*, **231**, 250–63 (*Aug.* 22, 1955).

In spite of the wide use of Hertzian potentials in special problems there appears to be no account of the general theory which is completely satisfactory—especially with regard to (i) the arbitrariness of the potentials and the relation between different equivalent representations of the same electromagnetic field, (ii) the derivation of the Hertzian potentials for such equivalent representations from the physical sources, and (iii) electromagnetic fields not *in vacuo*. It is the purpose of this paper to fill this gap. It is shown that the Hertzian potentials may be subjected to a new type of gauge transformation which leaves invariant the electromagnetic field they represent. The particular integrals of the inhomogeneous Maxwell equations are generalized, so that they may be subjected to a related gauge transformation which leaves invariant the physical sources of the field; this leads to a treatment of (ii) above, which appears to be new. Examples, including the Whittaker and Debye–Bromwich two-scalar representations, are given. Finally, the theorem is established that, for any electromagnetic field in any stationary material medium, the particular integral of Maxwell equations may be so chosen that in general the complementary function can be expressed in terms of only two scalar functions (components of Hertzian potentials), previously only known to hold for source-free regions *in vacuo*. A.

538.56 : 532.51

8928. Magneto-hydrodynamics. V. C. A. FERRARO. *Nature* [*London*] **176**, 234–7 (*Aug.* 6, 1955).

Brief report of a conference held at the Royal Society in May.

538.561 : 535.34.07

The maser—new type of microwave amplifier, frequency standard, and spectrometer. *See Abstr.* 8607

538.561 : 537.525

The appearance of some oscillating discharges. *See Abstr.* 8796

538.566 : 621.372.8

8929. Calculation of the phase and group velocity of surface waves. V. YA. SMORGONSKIĬ. *Radiotekhnika*, **10**, *No.* 5, 25–30 (1955) In Russian.

Plane and cylindrical dielectric-coated surfaces are examined. Phase velocity is plotted to a base of normalized dielectric thickness and it is shown that as the frequency decreases the velocity changes from that appropriate to free space to that expected in the dielectric. To obtain group velocity the phase velocity curves are first represented by an approximate expression which can be easily differentiated. For both kinds of surface wave there is a frequency where the group velocity is a minimum. Simple expressions are found for the minimum velocity and its depression below the low-frequency value. It is also shown that the greatest depression ($0{\cdot}0293c$) occurs for a dielectric constant of $3{\cdot}75$. S. C. DUNN

538.566 : 621.396.11

8930. A measurement of the velocity of propagation of very-high-frequency radio waves at the surface of the earth. E. F. FLORMAN. *J. Res. Nat. Bur. Stand.*, **54**, *No.* 6, 335–45 (*June*, 1955).

The velocity of propagation was measured at the surface of the earth, using a radio-wave interferometer operating at 172·8 Mc/s. The measured phase velocity, converted to velocity in vacuum, or the "free-space" value, was $299\,795{\cdot}1 \pm 3{\cdot}1$ km/sec. The uncertainty of $\pm 3{\cdot}1$ km/sec includes a 95% confidence interval for the mean, plus an estimated limit to the systematic error of $\pm 0{\cdot}7$ km/sec. Based on a 50% confidence interval (probable error of the mean), the uncertainty, including the estimated limit to the systematic error of $\pm 0{\cdot}7$ km/sec, becomes $\pm 1{\cdot}4$ km/sec. The accuracy with which the free-space phase velocity of radio waves could be measured was limited primarily by the accuracy to which the refractive index of air could be obtained from measured values of pressure, temperature, and relative humidity. A.

538.566 : 531.767 : 621.317.79.029.6

8931. A simplified form of microwave interferometer for speed measurements. G. W. G. COURT. *J. sci. Instrum.*, **32**, *No.* 9, 354–6 (*Sept.*, 1955).

The interferometer is particularly suitable for microwave applications, in particular, the determination of the Doppler frequency shift due to the motion of a target. One aerial is used and a hybrid junction separates transmitting and receiving paths, thus enabling a single oscillator to provide both transmitter and local oscillator power. A brief outline is given of an equipment developed for the measurement of the speed of road vehicles. Possible uses of the instrument in measurement of distance have been examined and its use in the study of microwave reflections from the sea surface is being investigated. A.

538.566 : 534.2

8932. On the scattering cross section of an obstacle. D. S. JONES. *Phil. Mag.*, **46**, 957–62 (*Sept.*, 1955).

Van de Hulst's theorem [Abstr. 1584 (1950)] giving the relation between the scattering cross-section and the scattered "amplitude" for an obstacle in an incident plane wave is derived by a calculation of the energy flow. In addition it is shown that, when the incident wave is due to a point source, the sum of the scattering and absorption cross-sections is determined by the value of a certain field in the neighbourhood of the source. The argument, which is based on energy considerations, could be applied to many scattering problems, e.g. sound waves or atomic collisions but is given explicitly for the electromagnetic field. A.

538.566 : 621.372.2

8933. Diffraction of microwaves by long metal cylinders. A. W. ADEY. *Canad. J. Phys.*, **33**, *No.* 8, 407–19 (*Aug.*, 1955).

A parallel-plate transmission line has been applied to the study of the amplitude and phase of the

diffracted electric field near metal cylinders of circular, square, and rectangular cross-section. The transverse dimensions of the cylinders are comparable with the wavelength (3·28 cm). A travelling dipole probe inserted in the line through a slot in one of the plates permits investigation of the field. Absorbing wedges at the boundary of the line make the plates effectively infinite in extent. Essentially plane wave conditions exist in the region of the measurements. Good agreement is obtained between calculation and experiment for circular cylinders. Measured results are given for square and rectangular cylinders. For one orientation of the rectangles the measured results are compared with approximate calculations. A.

538.566 : 621.396.11

8934. Diffraction of radio waves by a flat [rectangular] plate. Ya. I. Tetel'baum. *Radiotekhnika*, **10**, *No.* 4, 76–8 (1955) In Russian.

A plane polarized electromagnetic wave falls on the plate at an angle θ to the normal. To find the intensity of the diffused field at a given distance from the plate and at a given angle the principle of equivalence is applied. The plate is replaced by a double layer of electric and magnetic currents. The layer of magnetic current may be replaced by a double layer of electric currents. Hence the plate is replaced by a treble layer of electrical currents. The principle of complementarity is then applied which allows the given plate to be replaced by an opaque screen with a window of the shape of the given plate with simultaneous replacement of the incoming wave by one coming from the image of the source in the screen. From the density distribution of electrical and magnetic dipoles the secondary induced field at a given point from all elements of the plate is calculated by appropriate integration. The result is approximate as edge effects are not considered. It may be applied to particular cases with different relative positions of transmitter and receiver. M. W. Makowski (R)

538.566 : 621.396.11 : 621.372.8

8935. Scattering of electromagnetic waves from a "lossy" strip on a conducting plane. J. R. Wait. *Canad. J. Phys.*, **33**, *No.* 7, 383–90 (*July*, 1955).

One method for solving boundary value problems involving imperfectly conducting media is to assume, for a first approximation, that the surface currents are the same as if the media were perfectly conducting. Using this type of approximation, the problem of a line source of current situated over a plane surface, with a simple type of mixed boundary condition, is solved. For purposes of comparison the situation of an imperfectly conducting or "lossy" strip on an otherwise perfectly conducting plane surface is treated by an exact method employing elliptic wave-functions. The calculations of the scattered fields of the strip by the two methods indicate the extent of the validity of the initial assumption in the approximate procedure. A.

538.566 : 621.396.11 : 621.396.677

8936. Semi-asymptotic series for the diffraction of a plane wave at a cylinder. W. Franz and R. Galle. *Z. Naturforsch.*, **10a**, *No.* 5, 374–8 (1955) In German.

See also Abstr. 2023 (1955). Evaluating the relevant integrals by the saddle-point method, series are developed in terms up to the second order in ka ($k = 2\pi/\lambda$, a = radius). ka must be greater than about 2. S. C. Dunn

538.566

8937. Realization of the analogue of a birefringent quarter-wave plate at a wavelength of 3·2 cm. G. Raoult, R. Fanguin and A. Marcon. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 26, 2497–500 (*June* 27, 1955) In French.

Describes a circular waveguide component, designed to retard the phase of an H_{11} wave, polarized in a preferred plane, with respect to one polarized at right angles to this plane. It consists of a length of rectangular guide, connected at each end to a circular guide through tapered transitions, the width and height being chosen to give the required difference in phase velocity for the two polarizations. The performance is evaluated in terms of the departure from unity of the ellipticity of the polarization of the emerging wave, for an incident wave polarized at 45° to the direction of maximum phase shift. The ellipticity was found to be $>0·8$ over a 3% bandwidth. E. A. Ash

538.566 : 538.613

8938. A demonstration experiment of the Faraday effect with microwaves. J. Frey. *Siemens-Z.*, **29**, *No.* 7, 271–6 (*June*, 1955) In German.

An experiment, based upon an apparatus due to Rayleigh, shows the non-reversibility of microwaves when their plane of polarization is rotated in a magnetic field. Experimental details of the equipment are described. R. W. Fish

538.566 : 621.317.18

8939. Making electromagnetic waves visible. H. Kleinwächter. *Arch. elekt. Übertragung*, **9**, *No.* 3, 154–6 (*March*, 1955) In German.

Similar to Kock and Harvey's method of visual demonstration of amplitude and phase distribution of acoustic waves radiated by a supersonic source, phase and amplitude characteristics of electromagnetic radiation from dielectric aerials and waveguides are shown directly. The centimetric field to be investigated and a coherent auxiliary field are superimposed, both of approximately equal strength for reasonable visibility. A novel stroboscopic method is suggested, facilitating observation of wave propagation phenomena of varying intensity, such as the diffracted wave behind a conducting screen. Some remarkable photographs are reproduced of H_{10} waves leaving a 3 cm waveguide and being diverted by an insulating rod inserted in the waveguide throat, and of waves reflected by an inclined plane. A brief description of the experimental apparatus is given, using a reflex klystron in the phase comparator bridge. A. Landman (R)

538.566 : 621.396.11

8940. On the relationship between the distributions of intensity in radiating systems and their directional characteristics. G. Eckart. *Arch. elekt. Übertragung*, **9**, *No.* 4, 177–80 (*April*, 1955) In German.

It is shown on the basis of the analytical theory of the Fourier transformation that, for linear and infinitely plane radiating systems the relationship between the amplitude distribution on the radiator

and the directional radiation pattern is unique. The problem of scattering when a zone of small disturbances of the permittivity, or that of the velocity of sound, is struck by a wave, is considered for the case of electric and acoustic waves respectively. A mathematical solution is given for the determination of the distribution of the disturbing intensities; this is possible to obtain when an infinite family of directional characteristics of the scattering field is plotted by measurement. Z. F. WOJNAR

538.566.3

8941. Analysis of sky-wave field intensity. I. S. N. MITRA AND R. B. L. SRIVASTAVA. *Indian J. Sci.*, **29**, *No.* 4, 167–78 (*April*, 1955).

Presents a statistical analysis of field intensity of the internal short-wave stations of All India Radio over the period of a complete solar cycle (1942–52). The yearly, seasonal and monthly variations of the field intensity and their correlation with sunspot numbers are shown in a series of graphs. An interesting feature of the analysis is that the night-time field intensity has been found to be correlated with solar activity. This is rather inexplicable since no ionospheric absorption is usually assumed for the night-time propagation. A.

538.566.3

8942. The reflexion of vertically-incident long radio waves from the ionosphere when the earth's magnetic field is oblique. J. HEADING. *Proc. Roy. Soc. A*, **231**, 414–35 (*Sept.* 6, 1955).

Approximate equations are developed for the reflection of plane electromagnetic waves from a horizontally stratified anisotropic ionosphere, when the earth's magnetic field is in an arbitrary direction. Two distinct regions of height arise in the theory, each governed by its respective equations of propagation. For the special case of vertical incidence in an oblique magnetic field when the distribution of electron density is exponential, the equations for the lower region are solved analytically in terms of hypergeometric functions. The equations for the upper region are solved in terms of generalized hypergeometric functions under more general conditions, namely for oblique propagation when the plane of incidence coincides with the magnetic meridian. Explicit expressions in terms of Γ-functions of complex arguments are obtained for the reflection and transmission coefficients of the lower region, and for the reflection and conversion coefficients of the upper region. The theory is illustrated numerically by a typical model. A.

538.566.3 : 551.510.535

8943. Propagation of a plane wave in an anisotropic transparent ionized layer and propagation in a heterogeneous ionized layer. E. ARGENCE. *Physics of the ionosphere* [*Cambridge*] 288–98. See Abstr. 5763 (1955) In French.

Mathematical treatment. The method gives directly the differential equations for the paths of phase and energy. Results are given for the lateral displacement of ordinary and extraordinary rays at certain stations, which combined with experimental critical frequency data allow estimation of the horizontal gradient of ionization. Applications to the cases of normal incidence and propagation along the magnetic equator are considered. Propagation in a heterogeneous layer is considered in the absence of a magnetic field.

G. M. BROWN

MOLECULAR AND ATOMIC STRUCTURE 539.1

THEORY OF SOLID STATE 539.11

539.11

8944. Anharmonic lattice vibrations and the linear chain. D. J. HOOTON. *Z. Phys.*, **142**, *No.* 1, 42–57 (1955) In German.

The free energy of a crystal is expressed in terms of harmonic oscillations. The cases of weak and strong anharmonicity are treated separately. The results are applied to a linear crystal, numerical values being obtained by using data for solid He.

E. P. WOHLFARTH

539.11

8945. The cellular method for a close-packed hexagonal lattice, with applications to titanium. B. SCHIFF. *Proc. Phys. Soc. A*, **68**, *Pt* 8, 686–95 (*Aug.*, 1955).

The cellular method for obtaining electronic eigenvalues in crystals is formally extended to the close-packed hexagonal lattice, and the use of a double atomic cell is investigated, boundary conditions being obtained for a wave-function with an arbitrary wave vector. The symmetry properties of wave-functions at the zone centre are outlined. After calculating a potential function for the titanium ion-core, point boundary conditions are applied to determine eigenvalues for low-lying states at the centre of the zone in both modifications of the metal. The ground state is found to possess s-like symmetry in both cases. A.

539.11

8946. Application of the augmented plane wave method to copper. D. J. HOWARTH. *Phys. Rev.*, **99**, *No.* 2, 469–78 (*July* 15, 1955).

An application of the augmented plane-wave method of solving the periodic potential problem has been made to metallic copper. The aim is to investigate the value of the method and to learn details of the energy band structure of copper. The method has been found to converge very rapidly; eigenvalues of three- or four-figure accuracy can be obtained for any point in k-space without involving the solution of very large secular determinants. Throughout, good results can be obtained by considering only a single augmented plane wave; these appear to be good one-electron wave-functions by themselves, and the possible use of these as a starting point in a self-consistent calculation is discussed. The method proves suitable ground for the application of a high-speed computer, by which the present computation has been carried out. The numerical results for copper are not in agreement with the results of a cellular calculation. Recalculation of certain states by the cellular method indicates that the dominant

reason lies in the different potentials employed, the augmented plane-wave method dealing with a potential constant in a region between the atoms. The sensitivity of the energy levels upon the exact crystal potential has become more apparent, though copper may be expected to show greater sensitivity than other materials. The present calculation of the width of the 3*d* band is 3·935 eV, compared with 3·46 eV by the cellular method and 2·7 eV by the tight-binding method. The appearance of a high density of states near the top of the 3*d* band is confirmed. A.

539.11

8947. The surface energies of the alkali metals. J. W. TAYLOR. *Phil. Mag.*, **46,** 867–76 (*Aug.*, 1955).

The surface energies of sodium, potassium and lithium and their temperature coefficients have been measured experimentally. The values for lithium and sodium are in good agreement with similar theoretically calculated surface energies obtained by Stratton [Abstr. 636 (1954)]. The disparity between the experimental and theoretical surface energy values for potassium and that between the experimental and theoretical temperature coefficients of the three metals is discussed. A.

539.11

8948. Electron-phonon interaction in metals. J. BARDEEN AND D. PINES. *Phys. Rev.*, **99,** *No.* 4, 1140–50 (*Aug.* 15, 1955).

The rôle of electron–electron interactions in determining the electron–phonon interaction in metals is investigated by extending the Bohm–Pines collective description to take into account the ionic motion. Collective co-ordinates are introduced to describe the long-range electron–ionic correlations, and it is shown by a series of canonical transformations that these give rise to plasma waves and to coupled electron–ion waves which correspond to longitudinal sound waves. The dispersion relation for the sound waves is identical with that derived by Toya and Nakajima by self-consistent field methods. The velocity of these sound waves is calculated from first principles for sodium and is found to be in good agreement with experiment. The effective matrix element for the electron–phonon interaction is determined and is found to be identical for long wavelengths with that found earlier by Bardeen using a self-consistent field method which neglects exchange and correlation effects. The agreement with the earlier work is explained by the fact that the residual electron–electron interaction is of quite short range, so that an independent-particle treatment is rather well justified. The effects of Coulomb correlations on superconductivity are likewise shown to be small, so that the neglect of Coulomb interactions in the formulation of the superconductivity problem is justified. A.

539.11

8949. On the thermal ionization of trapped electrons in ionic solids. J. H. SIMPSON. *Proc. Roy. Soc. A*, **231,** 308–20 (*Sept.* 6, 1955).

The ground state of an electron trapped at a defect of the interstitial ion type in an ionic crystal is determined by a variation method in which the interaction between electron and lattice vibrations is treated on a dynamic basis. The results are compared with static calculations using a self-consistent method, and it is shown that for certain ranges of the low- and high-frequency dielectric constants an appreciable difference in energy may occur. A.

539.11

8950. Vacancies in monovalent metals. F. G. FUMI. *Phil. Mag.*, **46,** 1007–20 (*Sept.*, 1955).

The aim of this paper is to give a simplified calculation of the energy required to form a vacancy in a metal, which is applied to the noble and alkali metals. Although all such calculations are subject to considerable error unless many refinements are introduced, it is felt that such a calculation will give a useful indication of the various factors which determine the energy and the variation from metal to metal. An outline of the method is as follows. The metal is represented as a large spherical box in which the positive charge of the ions is uniformly distributed and the electrons are free to move. When an ion is removed from the centre of the sphere and spread over its surface, the energy of the free electrons changes by ΔE_{el}, because the electron waves undergo phase shifts in order to screen the vacancy and the volume of the metal box changes. ΔE_{el} is proportional to the Fermi energy of the metal E_F, and is estimated to be about $\frac{1}{5}E_F$. For the noble metals another relevant contribution to the energy needed to create a vacancy is that of the closed-shell repulsion between ions: for Cu this is about −0·3 eV. The energy to move a vacancy is also discussed; the electronic contribution is fairly small and in noble metals the term due to the closed-shell repulsion predominates. This is probably somewhat underestimated if one uses repulsive potentials valid in the neighbourhood of the equilibrium interatomic distance. The general agreement between the theoretical results and the experimental values for the energies to form and to move a thermal defect in the alkali and noble metals is satisfactory and suggests that vacancies are responsible for the transport of matter also in the alkalis. A.

539.11 : 538.114

8951. Electronic energy bands in iron. J. CALLAWAY. *Phys. Rev.*, **99,** *No.* 2, 500–9 (*July* 15, 1955).

The method of orthogonalized plane waves has been used to calculate the energy band structure of valence electrons in iron. Application of the results is made to the energy band theory of ferromagnetism. The exchange splitting of the energy bands and the tendency to ferromagnetism at absolute zero have been calculated. A.

539.11 : 538.61

8952. Magneto-optical properties of the exciton. A. G. SAMOĬLOVICH AND L. L. KORENBLIT. *Dokl. Akad. Nauk SSSR*, **100,** *No.* 1, 43–4 (1955) In Russian.

From their treatment of the theory of the energy levels of an exciton in a magnetic field, the authors conclude that the difference between the effective masses of the electron and the hole can be determined from observations on the Zeeman and Paschen–Back effects in the exciton. J. M. RADCLIFFE

539.11 : 539.152.2

8953. Knight's displacement in alloys. J. FRIEDEL. *J. Phys. Radium*, **16,** *No.* 6, 444–5 (*June*, 1955) In French.

The nuclear magnetic resonance shift in metals

resulting from electron distribution (Knight's shift) is shown theoretically to be independent of the existence of a second component, as in alloys, unless this is present in large amounts. This agrees with experiment.

D. H. WHIFFEN

539.11 : 539.2 : 669

8954. Theoretical structural metallurgy. A. H. COTTRELL. Second edition. *London*: *Edward Arnold* (1955) *viii* + 251 *pp.* Review in *Nature* [*London*] **176,** 229–30 (*Aug.* 6, 1955).

"Prof. Cottrell has rewritten the entire text, and has included an extra chapter."

MOLECULES 539.13

539.13

8955. The recombination of atoms. II. Causes of variation in the observed rate constant for iodine atoms. M. I. CHRISTIE, A. J. HARRISON, R. G. W. NORRISH AND G. PORTER. *Proc. Roy. Soc. A,* **231,** 446–57 (*Sept.* 20, 1955).

For Pt I, see Abstr. 3482 (1953). A re-investigation of the recombination of iodine atoms in presence of the inert gases over a wider range of experimental conditions has shown that the simple termolecular rate law $-d(I)/dt = k(I)^2(M)$ is not obeyed. For each of the inert gases k, the experimentally determined termolecular rate constant, increases with the ratio $(I_2)/(M)$, where (I_2) and (M) are the concentrations of iodine molecules and inert gas molecules respectively. The dependence of k on $(I_2)/(M)$ was obscured in previous work by the fact that a thermal effect, which results in a lowering of the apparent value of k as recombination proceeds, increases as $(I_2)/(M)$ increases and compensated for the real increase in k with $(I_2)/(M)$. Except at low $(I_2)/(M)$ values, k is a linear function of $(I_2)/(M)$, the gradient being the same for all five inert gases. A rapid termolecular reaction $I + I + I_2 = I_2 + I_2'$ with a rate constant $k = 470 \times 10^{-32}$ ml.^{2} mol.$^{-2}$ s^{-1} is postulated to explain the linear relationships. By extrapolation the values of k_M the third-order rate constants for the five inert gases are: He 0·67, Ne 0·92, A 1·84, Kr 2·25, Xe 2·99, in units of $10^{32} k_M$(ml.^{2} mol.$^{-2}$ s^{-1}).

A.

539.13 : 533.7

Thermal diffusion of gas mixtures and determination of force constants. *See Abstr.* 8554

539.132

8956. Force constants for substituted germanes. I. GeH_3Cl and GeD_3Cl. S. L. N. G. KRISHNAMACHARI. *Indian J. Phys* , **29,** *No.* 3, 147–50 (*March,* 1955).

A set of force constants are determined for GeH_3Cl and GeD_3Cl molecules using the Wilson F–G matrix method. This set reproduces the frequencies of the GeH_3Cl molecule to the nearest wave-number and those of the GeD_3Cl molecule to within a mean error of 0·81%.

A.

539.132

8957. Force constants of the radicals of XY_4 type. K. VENKATESWARLU AND M. G. KRISHNA PILLAY. Letter in *Curr. Sci.,* **24,** *No.* 5, 152–3 (*March,* 1955).

Force constants were calculated from observed Raman frequencies for radicals of T_d symmetry (AsS_4, SbS_4, NH_4, ND_4) following the method described by Cleveland [*Amer. J. Phys.*, **14,** 13 (1946)]. The normal frequencies were then determined using symmetry co-ordinates, and X–Y internuclear distances were deduced.

J. JACOBS

539.132

8958. Use of molecular quantum-mechanical approximations exemplified in the energy calculation of the H_3^- system. R. S. BARKER, H. EYRING, D. A. BAKER AND C. J. THORNE. *J. chem. Phys.,* **23,** *No.* 8, 1381–9 (*Aug.,* 1955).

Certain approximations of molecular quantum mechanics are examined. The size of the resultant error due to approximate methods for specific multicentre integral evaluations are cited. Examination of the Sklar approximate multicentre electron repulsion formula together with the generalizations and extensions of Vroeland and Löwdin allow application of the underlying approximation principle to three-centre nuclear attraction integrals. Specific approximate formulation of these integrals is given. The accumulation of computational errors arising from the many individual integral approximations in the energy evaluation of the linear H_3^- system is specifically examined. The ground-state energy of this system found from the Heitler–London and Wang-like treatments were −70 kcal/mole and −84 kcal/mole for the Sklar type approximations, −1 kcal/mole and −19 kcal/mole for the Mulliken type approximations, and −26 kcal/mole and −41 kcal/mole for exact integral evaluations. It is concluded that the Sklar type approximations, while preferable to the Mulliken type in a few specific evaluations lead like that formulation to considerable discrepancy between the over-all energy obtained for a polyatomic system. The Sklar approximations have the further disadvantage of requiring two-centre integral evaluations not needed in the over-all energy calculations. However, both the Sklar and the Mulliken approximations do give a rapid method for evaluating "best" distance and effective charge parameters for use with more extensive exact integral variational method calculations.

A.

539.132

8959. Use of the statistical field approximation in molecular physics. J. W. SHELDON. *Phys. Rev.,* **99,** *No.* 4, 1291–301 (*Aug.* 15, 1955).

The equations for the Dirac statistical field for an arbitrary molecule are obtained with boundary conditions, virial theorem, and an identity containing charge and energy integrals. Equations are obtained in which the forces between nuclei are related to kinetic energy. Numerical solutions of the statistical field equations for nitrogen are presented in graphical form, together with a discussion of numerical methods used to obtain them. The numerical results in conjunction with theoretical arguments show that it is not plausible that the statistical field should lead to binding for any molecule.

A.

539.132 : 537.56

The ionization and dissociation of complex molecules by electron impact. *See Abstr.* 8869

539.132

8960. The ratio of oscillator forces for the components of resonance-doublets of aluminium and lead. G. F. Parchevskiĭ and N. P. Penkin. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 379–83 (1955) In Russian.

The experimental technique has already been described by Penkin [*Zh. éksper. teor. Fiz.*, **17**, 355 (1947)]. The relations found are, for Al, $f\,3944/f\,3962 = 3{\cdot}44$ (1·7% error), and for Pb, $f\,3248/f\,3274 = 1{\cdot}98$ (1% error). A comparison of this method of "bends" of absorption lines with the method of complete absorption shows agreement to within experimental error. J. JACOBS

539.132

8961. On the representations, calculation and indefinite correction of the error in theoretical chemistry. A. Laforgue. *Cahiers de Phys.*, *No.* 57–58, 23–51 (*May–June*, 1955) In French.

An error potential and an error (vector-) function are introduced, expressing the difference between exact and approximate problems. This concept of error potential allows new methods of solution of the wave equation. Indeed, instead of the variational method one has a systematic reduction of error, taking account of the varying importance of the diverse electronic configurations; instead of perturbation calculations one has successive first-order perturbations containing a convergence criterion. In the method of LCAO the concepts of free valence and charge can now be made more precise. The concepts of "best orbital" and "effective parameter" are examined. A new method of constructing molecular orbitals is introduced on a quasi-symmetric condition at each bond and application is made in some detail to H_3 and H_3^+. J. JACOBS

539.132

8962. Vibrational analysis of the tantalum oxide bands. D. Premaswarup. *Indian J. Phys.*, **29**, *No.* 3, 109–20 (*March*, 1955).

Bands of the diatomic tantalum oxide molecule, TaO, in the region $\lambda 5000$–$\lambda 3400$ are photographed with different instruments under various dispersions including that of a second-order, 21 ft concave grating with 30 000 lines per inch. Complete data of the band heads lying in this region are given and compared with those given by earlier workers. All the more prominent bands are explained as forming members of two systems designated as A and C. The method of arriving at the vibrational analysis is discussed in detail. The vibrational constants ω_e and $x_e\omega_e$ for the ground and the two excited states involved are found to be 1040·0, 8·5; 901·4, 4·0 and 718·6, 2·2 cm^{-1}. A.

539.132

8963. Vibrational energy of deuterium cyanide. H. C. Allen, Jr, E. D. Tidwell and E. K. Plyler. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1356 (*July*, 1955).

The infrared spectrum of DCN has been observed in the frequency range 1900–8000 cm^{-1}. The constants in the quadratic expression for the vibrational energy are calculated. G. I. W. Llewelyn

539.132

8964. Effects of the bending mode of vibration on the hyperfine structure of ICN. A. Javan. *Phys. Rev.*, **99**, *No.* 4, 1302–6 (*Aug.* 15, 1955).

The bending mode of vibration in ICN introduces an asymmetry in the electric field gradient at the iodine nucleus. From an observed variation in the *l*-type doublet splittings of various hyperfine components for the $v_2 = 1$ state, the asymmetry parameter is determined as $\eta = 0{\cdot}0087$. It is found that the measured splittings can be accounted for fully by including 2nd-order perturbation terms arising from field asymmetry. The ratio $(eqQ)_{v=0}/(eqQ)_{v_2=1}$ is measured as 1·0039. This ratio and the observed value of η are discussed in terms of the molecular bending and I–C bonding electrons. A.

539.132

8965. Coupling of the out-of-plane bending mode in nitrates and carbonates of the aragonite structure. J. C. Decius. *J. chem. Phys.*, **23**, *No.* 7, 1290–4 (*July*, 1955).

The infrared absorption of polycrystalline samples of KNO_3 and $BaCO_3$ in the form of Nujol mulls has been observed between 11·3 and 12·5 μ under conditions such that the rotational lines of the NH_3 spectrum separated by 1·5 cm^{-1} could be clearly resolved. When the N^{15} or C^{13} content is increased to the order of 50%, fine structure is observed which is not present, e.g. in $NaNO_3$, which possesses a crystal structure similar to calcite. The fine structure is interpreted by postulating a force constant which couples the out-of-plane vibrations of nearest neighbours in the aragonite-type lattice. Very satisfactory agreement between the calculated and observed spectra is then found; in the case of $BaCO_3$, the vibrations of CO_3 ions which occur in isotopic isolation, as pairs, triplets and quadruplets are resolved. The significance of the coupling constant is discussed; in principle, it may be used to evaluate the dipole derivative for the mode under consideration. A.

539.132 : 539.133

8966. Semiempirical study of the H_2Cl transition complex through the use of hydrogen isotope effects. J. Bigeleisen and M. Wolfsberg. *J. chem. Phys.*, **23**, *No.* 8, 1535–9 (*Aug.*, 1955).

Linear and triangular structures for the H_2Cl transition complex have been analysed in terms of normal vibration theory and by an evaluation of the experimental data on the effect of hydrogen isotope substitution on the rate of reaction of hydrogen molecules and chlorine atoms. The frequencies of the bending vibrations are probably sufficiently small that their contribution to the relative rates can be expressed in terms of a small quantum correction of the order of $(hc/kT)^2(\omega_H^2 - \omega_{D,T}^2/24)$. The near classical behaviour of the bending frequencies for both linear and triangular structures of the H_2Cl complex serves to reduce the ratio of the frequency factors, $A_H/A_{D,T}$ in the Arrhenius equation from that expected from structural considerations alone. Quantitative agreement is found between the calculated and experimentally determined frequency factor ratios for the triangular complex. The "symmetrical" stretching frequencies, for both linear and triangular complexes respectively, have been evaluated from the relative rates of reaction of H_2 and HT with chlorine

atoms at 0°c and the known properties of the isotopic hydrogen molecules. This empirically evaluated parameter, together with thermodynamic data, and an estimate of the tunnel correction, suffice to calculate the relative rates of reaction of the isotopic hydrogen molecules with chlorine atoms as a function of temperature. Good agreement is found between the calculated rates for both linear and triangular structures and the available experimental data on HD, D_2 and HT. A.

539.132

8967. Solution of the wave equation for internal rotation of two completely asymmetric molecules. D. G. Burkhard and J. C. Irvin. *J. chem. Phys.*, **23**, *No.* 8, 1405–14 (*Aug.*, 1955).

The wave equation is derived from two completely asymmetric molecules undergoing mutual rotation about a common axis and subject to an arbitrary hindering potential. Matrix elements of the Hamiltonian are evaluated using the wave-functions which describe the mutual rotation of two symmetric groups. A.

539.132

8968. The electron structure and light absorption of the benzyl radical. W. Bingel. *Z. Naturforsch.*, **10a**, *No.* 6, 462–76 (1955) In German.

The ground state and the first excitation level of the benzyl radical are calculated by the method of valency structures [Pauling and Wheland, *J. chem. Phys.*, **1**, 362–74 (*June*, 1933)]; by the molecular orbital method and with the free electron model. The three methods agree with each other and with spectroscopic data. The last two methods are used to calculate the electron structure of the benzyl cation and anion in the ground state and in the first excitation state. C. TURNER

539.132

8969. Ionization potentials and charge-transfer spectra of substituted benzenes. L. E. Orgel. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1352–3 (*July*, 1955).

By suitable substitution the degeneracy of the $^2E_{1g}$ ground state is removed and a relation is found between the two new ionization potentials and the potential of benzene. A graph shows relations between these potentials, the charge-transfer energies for chloramil complexes, energies of absorption maxima for iodine complexes and for iodine monochloride complexes. C. TURNER

539.132

8970. Symmetry of the second excited singlet state of benzene. T. M. Dunn and C. K. Ingold. *Nature* [*London*] **176**, 65–8 (*July* 9, 1955).

Both B_{1u} and E_{2g} are considered. E_{2g} by three approximations. Reasons are given for deciding on the E_{2g} level and an analysis of the benzene 2 000 Å band system on this basis is given. C. TURNER

539.132 : 535.343

Intramolecular charge transfer spectra. *See Abstr.* 8608

539.132 : 535.343

Hyperfine structure in the inversion spectrum of $N^{14}H_3$. *See Abstr.* 8525

539.132

8971. Potential barriers about double bonds. N. W. Luft. Note in *J. phys. Chem.*, **59**, *No.* 6, 572–4 (*June*, 1955).

An approximate formula for the torsional potential barrier height is discussed; and application is made to ethylene and its deuterated derivatives. It appears that the torsional force constants for *cis* and *trans* configurations are almost identical. J. JACOBS

539.132

8972. Evaluation of certain three-center integrals. J. R. Streetman. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1348–9 (*July*, 1955).

If one centre is midway between the other two, then a one-electron three-centre integral may be accurately evaluated numerically using a two-dimensional analogue of one-dimensional trapezoid rule integration. G. I. W. LLEWELYN

539.132

8973. Modified atomic orbital method. I. The electronic structure of the ethylene molecule. K. Ohno and T. Itoh. *J. chem. Phys.*, **23**, *No.* 8, 1468–72 (*Aug.*, 1955).

It is well known that the energy intervals separating ionic and covalent states, as given by the conventional ASMO method, are too large. In order to avoid this difficulty, a modification of the non-empirical atomic orbital method is proposed, and is applied to the ethylene molecule. The principal point of the modification is to use different atomic orbitals for covalent and ionic structures of the molecules in order to assess more correctly the energies of the ionic structures. The results of the calculation are fairly satisfactory in that they are as good as those of the semiempirical method by Moffitt. Some errors due to assumptions and approximations made in this calculation are discussed. A.

539.132

8974. Properties of the hydrogen molecular ion. VI. The total electronic orbital angular momentum of the $1s\sigma_g$, $2s\sigma_g$ and $3s\sigma_g$ states. R. W. McCarroll and M. R. C. McDowell. *Proc. Phys. Soc. A*, **68**, *Pt* 9, 810–14 (*Sept.*, 1955).

For Pt V, see Abstr. 8126 (1955). The total electronic orbital angular momenta in the $1s\sigma_g$, $2s\sigma_g$ and $3s\sigma_g$ states of H_2^+ are calculated using the exact two-centre wave-functions. For the lowest of these states, calculations are also carried out using apparently quite accurate approximate wave-functions but the results obtained are seriously in error. A.

539.132 : 537.561

Ionization potential of the free HO_2 radical and the $H–O_2$ bond dissociation energy. *See Abstr.* 8871

539.132

8975. Molecular polarisability. The electro-optical polarisability tensor ellipsoids of naphthalene, and the α- and β-fluoro-, -chloro-, -bromo-, and -iodo-naphthalenes. C. G. Le Fèvre and R. J. W. Le Fèvre. *J. Chem. Soc.*, **1955**, 1641–6 (*June*).

The molar Kerr constants for the substances named have been measured at infinite dilution in carbon tetrachloride, and the half-axes of the polarizability ellipsoids estimated. While the substitution of an α- or β-hydrogen atom of naphthalene by halogen

does not cause the observed value for the average polarizability of the resulting halogenonaphthalene to deviate markedly from that expected, yet analysis into b_1, b_2 and b_3 suggests that exaltations and depressions are in fact to be found for the directions collinear with and normal to the C–X bond. The molar Kerr constants of β-halogenonaphthalenes are 2–3 times as large as those of the related α-isomers. A.

539.133

8976. Dipole moment and electronic structure of excited molecules. E. Lippert. *Z. Naturforsch.*, **10a**, *No.* 7, 541–5 (1955) In German.

Solvent interactions shift molecular energy levels and thence the absorption and fluorescence frequencies in a manner dependent on the solvent orientation and thence on the solute dipole moment. From the frequency shift dependence on the refractive index and dielectric constant of the solvent, $\mu_{excited}$ can be obtained to 20%. For 4-dimethylamino-4′-nitrostilbene $\mu_{ex} \sim 32$ D indicating at least 50% zwitterion character in the excited state. D. H. WHIFFEN

539.133

8977. Calculation of the dipole moments of trisubstituted benzenes. D. V. G. L. Narasimha Rao. *Indian J. Phys.*, **29**, *No.* 2, 49–54 (*Feb.*, 1955).

A general method is given for the calculation of dipole moments of 1, 2, 4 tri-substituted benzenes taking into account the induced effects, similar to the treatment of Smallwood and Herzfeld for the disubstituted compounds. The calculated values are given for five compounds for which the observed values are available and a comparison is made between the calculated and observed values. A.

539.133

8978. Structure and internal motion of C_2F_6 and Si_2Cl_6 vapors. D. A. Swick and I. L. Karle. *J. chem. Phys.*, **23**, *No.* 8, 1499–504 (*Aug.*, 1955).

The molecular structure and internal motion were investigated by means of the sector-microphotometer method of electron diffraction. Both molecules exhibit hindered internal rotation, with equilibrium in the *trans* position. The interdependence of the potential barrier and the modes of vibration other than the torsional is presented graphically. The values for the bonded distances are: C—F = 1·32 ± 0·01 Å, C–C = 1·56 ± 0·03 Å with ∠CCF = 109½° ± 1½° and Si—Cl = 2·01 ± 0·01 Å, Si—Si = 2·24 ± 0·06 Å with ∠SiSiCl = 109½° ± 1°. A.

539.133

8979. Proof of the staggered configuration of ethyl chloride. R. S. Wagner and B. P. Dailey. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1355 (*July*, 1955).

Calculated values of the rotational constants of CH_2DCH_2Cl for the staggered configuration are in good agreement with observed values obtained from microwave spectrum data. G. I. W. LLEWELYN

539.133

8980. Frequency shift of the CO stretching band in polypeptides and proteins. S. Krimm. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1371–2 (*July*, 1955).

A theoretical explanation is proposed for the difference in the frequency of the CO stretching mode in folded (α) and extended (β) molecular chains.

G. I. W. LLEWELYN

539.133

8981. Ring formation and molecular weight distributions in branched-chain polymers. I. F. E. Harris. *J. chem. Phys.*, **23**, *No.* 8, 1518–25 (*Aug.*, 1955).

The theory of molecular weight distributions in branched-chain polymers is extended to include possible intramolecular reaction leading to ring formation. The problem is more complicated than the non-cyclic case in that, in addition to the more complex combinatory and algebraic considerations, it is necessary to consider geometric restrictions on the number and relative probability of many configurations. Two approximate models for describing the extent of ring closure are investigated. The first of these, in which it is assumed that spatial restrictions may be ignored, predicts far too many structures for large molecules with many rings, and as a result always predicts gel formation. In the second approximation it is assumed that geometric restrictions limit the number of rings so that the probability of ring closure is independent of molecular weight, but only depends upon the density of available ends. This model predicts that ring closures will shift the gel point to higher extents of reaction, producing at volumes larger than a "critical volume," completely soluble polymers even at complete reaction. The dependence of the molecular weight distribution on the experimental variables is discussed in some detail. A.

ATOMS . NUCLEUS . ISOTOPES 539.15

539.152.1

8982. Low-energy physics from a high-energy standpoint. L. I. Schiff. *Science*, **121**, 881–4 (*June* 24, 1955).

A lucid survey in elementary terms of the information gained from high-energy experiments about nuclear charge distributions and ground and low-excited states of nuclei. Photo-disintegration, μ-meson capture and scattering and high-energy electron scattering are discussed in particular.

G. E. BROWN

539.152.1

8983. Statistical theory of the nucleus. P. Gombás, E. Mágori, B. Molnár and É. Szabó. *Ann. Phys. [Leipzig]* **16**, *No.* 1–2, 93–6 (1955) In German.

Previous calculations [Abstr. 6690 (1952), 7028 (1953)] of the nuclear density, energy and exchange-energy based on a Yukawa two-particle interaction potential have been extended to the case of exponential and Gaussian potentials. G. E. BROWN

539.152.1

8984. On the absence of stable Tc and Pm isotopes and other anomalies in the distribution of β-stable nuclei. A. V. Savich. *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 361–8 (1955) In Russian.

The criterion of the maximum binding energy of isobars is used to derive empirical regularities in the distribution of atomic nuclei in an A (mass no.) *v.* N–Z (neutron excess) diagram. The absence of β-stable nuclides for certain neutron and proton (Tc

and Pm) numbers and other exceptions from empirical regularities can be explained, according to the author, only by shell closures at 20, 28, 40, 50, 58, 70, 82 and 126 nucleons. S. DEDIJER

539.152.1

8985. Coupling between surface oscillations of the nucleus and single-nucleon excitation. A. S. DAVÝDOV. *Zh. éksper. teor. Fiz.*, **29**, *No.* 1(7), 75–84 (1955) In Russian.

The formulation of the A. Bohr model of collective motion is carried out. The probability of excitation of collective motion by a single nucleon is calculated. G. E. BROWN

539.152.1

8986. Scattering of high energy nucleons by non-uniform nuclei. G. Z. SHAH AND K. M. GATHA. *Curr. Sci.*, **24**, *No.* 5, 151–2 (*March*, 1955).

The optical model is generalized to non-uniform nuclear densities and 90 MeV total scattering is reasonably accounted for with the parameters derived from the 340 MeV data. P. T. MATTHEWS

539.152.1

8987. Evaluation of the imaginary part of the nuclear complex potential. A. M. LANE AND C. F. WANDEL. Letter in *Phys. Rev.*, **98**, *No.* 5, 1524–5 (*June* 1, 1955).

Experimental values of $V_{imaginary}$ at 0, 4·1, 9·5, 14 and 22 MeV (deduced from n and p scatterings on heavy nuclei) can be accounted for in terms of nucleon–nucleon collisions (with experimental 2-body cross-sections) [Goldberger (1948), also Abstr. 1696 (1954)]. The observed decrease of V_i at low energies is due to the operation of the exclusion principle. W. J. SWIATECKI

539.152.1

8988. On the collective rotational motion of the nucleus. I. R. NATAF. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 26, 2510–12 (*June* 27, 1955) In French.

The rotational motion of the liquid drop is not inconsistent with the shell model. Methods of obtaining the Hamiltonian of the former from the latter are discussed. P. T. MATTHEWS

539.152.1

8989. Some relations concerning a certain implicitly defined non-Hermitian operator. A. HERPIN AND C. MERCIER. *C.R. Acad. Sci.* [*Paris*] **241**, *No.* 2, 177–8 (*July* 11, 1955) In French.

Some general properties of a type of implicitly defined non-Hermitian operator occurring in a generalization of the cloudy crystal ball model. P. T. MATTHEWS

539.152.1

8990. A study of nucleon forces with repulsive cores. I. The effect of cores of finite strength. J. R. BIRD AND M. A. PRESTON. *Canad. J. Phys.*, **33**, *No.* 8, 399–406 (*Aug.*, 1955).

Consideration is given to repulsions of finite strength and, for an exponential attractive potential and for the ^1S n–p system, it is shown to what accuracy the core may be replaced by an infinite one with a smaller radius. A.

539.152.1

8991. Determination of the strength function of nuclear energy levels. S. E. DARDEN. *Phys. Rev.*, **99**, *No.* 3, 748–51 (*Aug.* 1, 1955).

An investigation of the average reduced neutron width to spacing ratio, or strength function, $\langle\gamma_0^2\rangle/\overline{D}$, of nuclear levels has been carried out as a function of atomic weight and neutron energy. The experiment was performed by measuring deviations from exponential attenuation of a beam of neutrons passing through samples of various elements. Deviations from exponential attenuation were observed by comparing transmissions of thin samples for neutron beams filtered through thick samples with transmissions of thin samples for unfiltered beams. A.

539.152.1

8992. Energy eigenvalues for a spherical well with an exponentially diffuse boundary. A. E. S. GREEN AND K. LEE. *Phys. Rev.*, **99**, *No.* 3, 772–7 (*Aug.* 1, 1955).

The discrete energy eigenvalues of a spherical well with an exponentially diffuse boundary are obtained to a good approximation for a range of well parameters of interest in nuclear physics. The method used involves replacing the centrifugal energy in the exponentially diffuse region by an approximate expression which leads to analytic solutions of the wave equation. The matching of the internal and external wavefunctions is then accomplished by the use of specially prepared graphs and tables. The eigenvalues and eigenfunctions are thought to be of interest in connection with studies of the independent particle model of the nucleus. A.

539.152.1

8993. Independent particle model of the nucleus. I. Interparticle forces and configuration mixing. C. LEVINSON AND K. W. FORD. *Phys. Rev.*, **99**, *No.* 3, 792–802 (*Aug.* 1, 1955).

A simplified method of obtaining the direct interaction between two identical nucleons in the nuclear shell model is given for the special case of singlet forces. Configuration interaction is included in the method. A semi-empirical analysis of simple two and three particle nuclear spectra is outlined which enables one to determine properties of the two-body perturbing interaction provided many body forces are negligible and coupling to the nuclear surface is weak. Corrections to the singlet force formalism due to triplet central and tensor forces are discussed. Formulae are given for magnetic dipole and quadrupole moments and magnetic dipole transition rates for mixed three-particle configurations. The effect of weak surface coupling on multi-particle configuration will be given in Pt II, and a detailed discussion of the spectra of two isotopes of calcium in Pt III. A.

539.152.1

8994. Particle states in spheroidal nuclei. S. A. MOSZKOWSKI. *Phys. Rev.*, **99**, *No.* 3, 803–9 (*Aug.* 1, 1955).

Particle motion in a spheroidal box has been studied by making an appropriate co-ordinate transformation so that the potential appears as spherically symmetric. The effect of the non-sphericity then appears as a change in kinetic energy for which the perturba-

tion matrix elements can be evaluated. Matrix elements between states in different major shells are small. The energy levels and wave-functions (defined in the transformed co-ordinate system) can then be calculated by the customary techniques of matrix diagonalization. This method was used to obtain energy levels of a spheroidal box both without and with an additional spin-orbit term of the magnitude suggested by nuclear shell systematics. Corresponding results for distorted wells of finite depths appear to be rather simply related to those for a box. Nuclear deformations predicted by this picture are in qualitative agreement with experimental values, and are, in general, considerably smaller than the values implied by a hydrodynamical model. A.

539.152.1

8995. Nuclear internal momentum distributions. J. M. Wilcox and B. J. Moyer. *Phys. Rev.*, **99**, *No.* 3, 875–85 (*Aug.* 1, 1955).

The nuclear internal momentum distributions of protons in light nuclei have been studied with the 340 MeV scattered proton beam from the synchrocyclotron. The two protons from a quasielastic scattering event are detected in coincidence, and the energy of one of them is magnetically analysed. In the limit of the impulse approximation, conservation of energy and momentum can be employed to solve for the momentum of the struck proton. The best fit to the experimental data for beryllium was obtained with a Gaussian momentum density distribution with a $1/e$ value of about 20 MeV. Fermi (rectangular) and Chew–Goldberger distributions did not fit so well. Qualitative differences were observed between lithium beryllium and boron. The observed lithium spectrum was interpreted as being caused by two types of protons in lithium; two core protons that have a large momentum distribution and a third proton that has a rather low kinetic energy. This speculation was supported by the shape of the observed lithium spectrum, and by the relative yields from lithium, beryllium and deuterium. The spectrum observed from beryllium indicated that the protons in beryllium have a larger momentum than the protons in the lighter elements studied. There were some indications that the fifth proton in boron may behave similarly to the third proton in lithium.

A.

539.152.1

8996. On the development of the compound nucleus model. E. P. Wigner. *Amer. J. Phys.*, **23**, *No.* 6, 371–80 (*Sept.*, 1955).

The cross-sections of certain nuclear reactions, as functions of energy, show sharp maxima and low values between the maxima, thus exhibiting a great similarity to line spectra. The compound nucleus theory was originally designed to explain this structure and to describe the corresponding nuclear reactions. After a brief description of the picture which the compound nucleus theory presents for these reactions, the story of the extension of the theory to describe a wide variety of reactions is presented. This includes an outline of the mathematical concepts which the extended theory uses. The last part of the article deals with the connection between the so-called principle of causality, which expresses the fact that the scattered particle wave cannot leave the nucleus before the incident particle wave has reached it, and the formulae of the generalized compound nucleus theory. A.

539.152.1

8997. Spin-orbit coupling and the density distribution in heavy nuclei. R. J. Blin-Stoyle. *Phil. Mag.*, **46**, 973–81 (*Sept.*, 1955).

The spin–orbit coupling experienced by a nucleon in a nucleus is interpreted in terms of a neutral two-body spin–orbit potential. An expression of the Thomas form is obtained for the effective spin–orbit potential. It is shown that the spin–orbit splitting in heavy nuclei can be explained satisfactorily if the nuclear density distribution has a finite transition region at the surface and if the neutron distribution has a larger radius than the proton distribution. A.

539.152.1

8998. Electromagnetic properties of the deuteron. I. Charge density and quadrupole moment. J. Bernstein and A. Klein. *Phys. Rev.*, **99**, *No.* 3, 966–73 (*Aug.* 1, 1955).

The Tamm–Dancoff method is applied to the calculation of the electrostatic properties of the deuteron. The state vector is assumed to contain amplitudes for at most two mesons in the field, but the possible presence of nucleon–antinucleon pairs is ignored. A formula applicable to the calculation of any multipole moment is derived and used to compute the leading exchange corrections, of order g^2 and g^4 respectively, to the usual expression for the quadrupole moment. For a suitably chosen hard-core wave-function the ratio of successive terms is about one-tenth, and the g^2 term is itself only a few per cent of the total effect. A.

539.152.1

8999. Predicted 0+ level in $_{40}Zr^{90}$*. K. W. Ford. Letter in *Phys. Rev.*, **98**, *No.* 5, 1516–17 (*June* 1, 1955).

The assumption of a discontinuity of ~0·9 MeV at $Z = 40$, associated with the separation between the $g_{9/2}$ and $p_{1/2}$ sub-shells, suggests, semi-quantitatively, a spectrum for Zr^{90} consisting of the sequence: 0+ (ground state), 0+, 2+, 5−, 4−, 4+, 6+, 8+. (See abstract following.) W. J. Swiatecki

539.152.1

9000. Evidence for a 0+ first excited state in Zr^{90}. O. E. Johnson, R. G. Johnson and L. M. Langer. Letter in *Phys. Rev.*, **98**, *No.* 5, 1517–18 (*June* 1, 1955).

This is found in measurements on a 1·75 MeV conversion line in a 40 cm magnetic spectrometer with a strong Y^{90} source. (See preceding abstract.)

W. J. Swiatecki

539.152.1

9001. Energy levels of As^{75}. A. W. Schardt and J. P. Welker. *Phys. Rev.*, **99**, *No.* 3, 810–24 (*Aug.* 1, 1955).

The excited levels of As^{75} were investigated by studying the decay schemes of Se^{75} and Ge^{75}. β- and γ-ray energies, internal conversion coefficients and relative transition intensities were measured. In addition, coincidence and γ-γ directional correlation experiments were performed. Se^{75} electron-captures to a level at 402 keV in As^{75}; eleven transitions of

indicated energy and multipolarity follow the electron-capture process: 25, 66($M1 + E2$), 81, 97($E2$), 121($M1 + E2$), 136($M1 + E2$), 199 ($M1 + E2$), 265($M1 + E2$), 280($E2$), 305 and 402($M1$) keV. Ge^{75} decays by emission of negative β-groups with end-point energies of 1·19, 0·98, 0·92, 0·72 and 0·55 MeV. Subsequently, six γ-rays with the following energies are emitted: 66, 199, 265, 427, 477 and 628 keV. A level scheme for As^{75} is proposed and plausible spin and parity assignments are discussed. The evidence indicates that most of the levels of As^{75} have spin 1/2 or 3/2 and are not single-particle shell-model states. A.

539.152.1

9002. The low lying levels of ^{25}Al. L. L. GREEN, J. J. SINGH AND J. C. WILLMOTT. *Phil. Mag.*, **46**, 982–8 (*Sept.*, 1955).

The γ-ray spectrum at the 825 keV resonance in Mg^{24} has been investigated and the angular distributions of the three initial γ-rays measured. The spins and parities of the ground state and first excited states are confirmed as $5/2^+$ and $1/2^+$ respectively, and the second excited state is shown to be $3/2^+$. Evidence is presented which lends a measure of support to the view that a level exists in Al^{25} at 1·92 MeV. A.

539.152.1 : 539.155.4

9003. Mass measurement and excited states of F^{21}. N. JARMIE. Letter in *Phys. Rev.*, **99**, *No.* 3, 1043–4 (*Aug.* 1, 1955).

Proton groups from the $F^{19}(t, p)F^{21}$ reaction have been observed, indicating a ground-state mass of 21·005 703 ± 0·000 025 a.m.u., and excited states at 0·33, 1·11, 1·84 and 2·16 MeV. J. J. WILKINS

539.152.2

9004. Exchange moment contributions to a modified shell model. A. RUSSEK. *Phys. Rev.*, **99**, *No.* 3, 834–43 (*Aug.* 1, 1955).

The longitudinal exchange contribution to the nuclear magnetic moment that follows from a rather general modified shell model is studied. It is shown that for a heavy nucleus whose state can be expanded as a linear combination of certain very reasonable independent particle configurations, the longitudinal exchange contribution to the magnetic moment can be expressed, independent of the amplitudes of these states, in terms of a correction to the orbital Landé g-factor that appears in the single particle ordinary moment operator. The magnitude of this correction is simply given in terms of the fraction of the neutron–proton two-body potential that is charge-exchange and spin-independent. Being independent of the configuration amplitudes, this result is expected to hold even if the core behaves as a liquid drop. Calculations assuming roughly half of the nuclear force to be charge exchange in nature reasonably account for the deviations from the values predicted by the shell model of the magnetic moments of those nuclei which consist of a single odd nucleon outside a doubly magic core. The exchange contributions generally improve the moment agreement of other nuclei in the $j = l - 1/2$ cases, but make the agreement in the $f_{7/2}$ and $g_{9/2}$ cases poorer. A.

539.152.2

9005. Nuclear moments and shell structure. S. SENGUPTA. *Indian J. theor. Phys.*, **2**, *No.* 3, 121–58 (*Nov.*, 1954).

A review of how far theory can account for the experimental results on nuclear moments. The shell structure of the nucleus has been critically examined to see how far it can be made to account for the magnetic and electric moments of different nuclei and how far different schemes of coupling are successful in solving the apparent inconsistencies. It is pointed out that for several nuclei (B^{11} and K^{39} for example) the independent particle model cannot explain the magnetic moments whatever coupling scheme is used. 48 refs. D. J. PROWSE

539.152.2

9006. Isotopic spin, from the experimental point of view, at low energies. M. DEUTSCH. *Cahiers de Phys.*, *No.* 57–58, 1–9 (*May–June*, 1955) In French.

A review of isotopic spin in nuclear physics—masses and excited states of mirror nuclei and triads, reactions with heavy particles and γ-transitions. P. T. MATTHEWS

539.152.2

9007. Ratio of magnetic moments of Co^{58} and Co^{60}. J. C. WHEATLEY, D. F. GRIFFING AND R. D. HILL. Letter in *Phys. Rev.*, **99**, *No.* 1, 334–5 (*July* 1, 1955).

A direct determination of the ratio was made using the method of aligning Co nuclei in Tutton salts at low temperatures. The ratio is obtained from the temperature variation of the counting rates of the γ-rays emitted by the nuclei by assuming for them certain definite decay schemes. E. P. WOHLFARTH

539.152.2 : 535.331

9008. The magnetic dipole moment and spin of $_{69}Tm^{169}$. K. H. LINDENBERGER. *Z. Phys.*, **141**, *No.* 4, 476–85 (1955) In German.

The thulium spectrum has been examined in the range 2 400–4 000 Å with a Fabry–Pérot interferometer. 26 lines have a doublet structure and at 3 848 Å a third weak component has been observed. 17 lines do not split and no line has more than two strong components. The spin of Tm^{169} is hence determined to be $I = \frac{1}{2}$. The magnetic dipole moment has been determined from the splitting of the classified Tm II-lines by three independent methods as $-0{\cdot}20_5 \pm 0{\cdot}02$ nuclear magnets. These results do not agree with those to be expected from the configuration given by the nuclear shell model. D. J. PROWSE

539.152.2

9009. Configuration mixing and quadrupole moments of odd nuclei. H. HORIE AND A. ARIMA. *Phys. Rev.*, **99**, *No.* 3, 778–85 (*Aug.* 1, 1955).

The quadrupole moments of odd nuclei are calculated from the standpoint of configuration mixing. The calculations are based upon the simple perturbation theory. The quadrupole moments of odd-neutron nuclei are due to the excitation of one or more protons. The quadrupole moments of odd-proton nuclei also contain the quadrupole moments of the initial configuration. The agreement between the calculated and observed values are fairly good except for the nuclei with very large quadrupole moments. A.

539.152.2

9010. Quadrupole moments of Ta^{181} and Lu^{175}. T. KAMEI. *Phys. Rev.*, **99**, *No.* 3, 789–91 (*Aug.* 1, 1955).

The hyperfine structure of the spectrum of Ta I was studied by means of a hollow-cathode discharge tube and a Fabry–Pérot étalon, in order to determine the quadrupole moment of Ta^{181}. The calculation was carried out for the quadrupole coupling constants of the levels $^4F_{3/2}$, $^4P_{3/2}$, $^4F_{5/2}$, $^4F_{7/2}$ and $^4F_{9/2}$ of the configuration $5d^3\,6s^2$, in which the three $5d$-electrons are combined by an intermediate coupling. This yielded the result that $Q(Ta^{181}) = (+4{\cdot}3 \pm 0{\cdot}4)\times10^{-24}\,cm^2$, in which the polarization correction (due to Sternheimer) is taken into account. The value of $Q(Lu^{175})$ was calculated from the data given in the literature, and was found to be $(+5{\cdot}7 \pm 0{\cdot}3)\times10^{-24}\,cm^2$. A.

539.152.2 : 535.331

9011. The quadrupole moment of $_{57}La^{139}$. G. LÜHRS. *Z. Phys.*, **141**, *No.* 4, 486–99 (1955) In German.

The hyperfine structure of the La I and La II spectra have been observed in the range 4 500 to 6 700 Å with a Fabry–Pérot interferometer. The quadrupole splitting factors for four terms and four lines have been determined. From these figures the quadrupole moment is given as $0{\cdot}3 \pm 0{\cdot}1\times10^{-24}\,cm^2$. The magnetic splitting factors for 18 La I and 7 La II terms are given. D. J. PROWSE

539.152.2

9012. "Brute force" polarization of In^{115} nuclei; angular momentum of 1·458-eV neutron resonance. J. W. T. DABBS, L. D. ROBERTS AND S. BERNSTEIN. Letter in *Phys. Rev.*, **98**, *No.* 5, 1512–13 (*June* 1, 1955).

The transmission of 0·075 eV, ~80% polarized neutrons through a laminated In metal sample (0·5×1·5×3·5 cm), cooled down to 0·035°K and in a magnetic field of 1 150 gauss, was measured for neutrons polarized parallel and antiparallel to the nuclear spins. The change of ~7% in transmission corresponds to a nuclear polarization of ~2%; the sign of the effect gives $J = I + \frac{1}{2} = 5$ for the spin. W. J. SWIATECKI

539.152.2

9013. The nuclear orientation of cobalt 57. G. R. BISHOP, M. A. GRACE, C. E. JOHNSON, A. C. KNIPPER, H. R. LEMMER, J. PEREZ Y JORBA AND R. G. SCURLOCK. *Phil. Mag.*, **46**, 951–6 (*Sept.*, 1955).

This was studied by the method of nuclear alignment in cobalt rubidium sulphate. By determining the angular distribution of the γ-radiation following its decay and its plane of polarization it is shown that the 123 keV transition is predominantly $M1$ with a small admixture of $E2$ ($\delta = +0{\cdot}19 \pm 0{\cdot}02$). A.

539.152.2

9014. Spin echoes with four pulses. G. J. B. CRAWFORD. Letter in *Phys. Rev.*, **99**, *No.* 2, 600 (*July* 15, 1955).

539.152.2

9015. Low-field magnetic resonance. M. A. GARSTENS AND J. I. KAPLAN. *Phys. Rev.*, **99**, *No.* 2, 459–63 (*July* 15, 1955).

Low-field magnetic resonance has been investigated for linearly and circularly polarized radio-frequency radiation for both the saturated and unsaturated case using modified Bloch equations for both. For the circularly polarized case, a quantum mechanical solution is presented. Experimental verification for the linearly polarized case has been obtained. See also Abstr. 5802, 11332 (1954). A.

539.152.2

9016. Spin resonance in metals as a function of the Overhauser effect. J. I. KAPLAN. *Phys. Rev.*, **99**, *No.* 4, 1322–3 (*Aug.* 15, 1955).

The polarization of the nuclear spin states by saturating the electron spin levels as predicted by Overhauser is shown to alter the electron spin resonance absorption line shape. It is shown that under certain stringent conditions the line shape may depend upon the sweep direction of the magnetic field H_0. The theory is developed under the assumption of no skin depth broadening. A.

539.152.2

9017. Experimental study of nuclear resonance. P.-M. DENIS. *Arch. Sci.* [*Geneva*] **8**, *No.* 2, 113–36 (1955) In French.

An account of the theory and experimental details with especial emphasis on the measurement of relaxation times. D. H. WHIFFEN

539.152.2

9018. On the influence of a field inhomogeneity with nuclear magnetic resonance effect. U. DOLEGA. *Ann. Phys.* [*Leipzig*] **16**, *No.* 3–4, 153–62 (1955) In German.

The influence of inhomogeneity in the static field on the line shape in nuclear magnetic resonance absorption for slow passage is investigated theoretically for spherical and cylindrical probes. Theory and experiment are shown to be in agreement. D. H. WHIFFEN

539.152.2 : 537.533.7

Calculation of the quadrupole moment in the scattering of electrons. *See Abstr.* 8824

539.153

9019. Role of the continuum in superposition of configurations. H. SHULL AND P.-O. LÖWDIN. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1362 (*July*, 1955).

An early paper by Hylleraas [*Z. Phys.*, **48**, 469 (1928)] on the ground state of helium by the method of superposition of configurations is re-examined and extended. G. I. W. LLEWELYN

539.153

9020. Hyperfine structure anomaly in atomic *p*-states. C. SCHWARTZ. Letter in *Phys. Rev.*, **99**, *No.* 3, 1035–6 (*Aug.* 1, 1955).

The hyperfine anomaly is calculated for the $p_{1/2}$ and $p_{3/2}$ states of Ga taking into account the admixture of s-electron states. G. E. BROWN

539.153

9021. On a metastable energy state of the negative helium ion. E. HOLØIEN AND J. MIDTDAL. *Proc. Phys. Soc. A*, **68**, *Pt* 9, 815–23 (*Sept.*, 1955).

By applying the selection rules of auto-ionization to the $(1s2s2p)^4P$ state of the negative helium ion, it is shown that only the $^4P_{5/2}$ energy level is not liable to auto-ionization. Provided the lowest triplet state of the atom has positive electron affinity, this ionic state

is metastable in the same sense as the triplet state. A thorough energy calculation of the quartet state of the ion has been carried through, and a positive electron affinity of at least 0·075 eV is found, enough to explain the experimental observation of it in the mass spectrograph as reported by Hiby (1939). The unexplained line 310 061 cm^{-1} (322·5 Å) observed in the vacuum ultraviolet by Kruger may then probably correspond to the transition $(2s2p^2)\ ^4P - (1s2s2p)\ ^4P$ in He^-, yielding an error of only 0·083 eV in the energy calculations. A.

539.153 : 535.33

9022. Spectroscopic measurement of transition probabilities of the cadmium atom. J. P. A. VAN HENGSTUM. *Utrecht University Dissertation* (1955) 59 *pp.* In Dutch with summary in English (1 *p.*).

From intensity measurements of radiation from a.c. and d.c. carbon arcs in air for arc temperatures between 4400 and 6500°K. The excitation is found to be thermal. Transition probabilities are found for ^3S–^3P and ^3D–^3P triplet components and for singlets 5^1D_2–5^1P_1 and 6^1D_2–5^1P_1 and for resonance line 5^3P_1–5^1S_0. 5^1P_1–5^1S_0 could not be determined due to self-absorption. A table of relative and absolute transition probabilities is given, the sum rule is checked, and the relative transition probabilities of Cd are compared with those of Zn and Hg. 42 references. C. TURNER

539.153 : 539.132 : 535.342

9023. Absorption studies of helium metastable atoms and molecules. A. V. PHELPS. *Phys. Rev.*, **99**, *No.* 4, 1307–13 (*Aug.* 15, 1955).

The lifetimes of the metastable states of the helium atom and molecule in pure helium have been determined by using a time-sampling technique for the measurement of the time-varying optical absorption caused by the various metastables. The measured loss of helium singlet metastable atoms indicates destruction after diffusion to the wall, upon collisions with single atoms, and by conversion into triplet metastable atoms in collisions with thermal electrons. The triplet metastable atoms are destroyed upon diffusion and by collisions with two neutral atoms which result in the formation of molecules in the $2^3\Sigma_u^+$ state. These molecules have a natural lifetime of at least 0·05 second and are destroyed upon diffusion to the wall and by collisions with slow electrons or other metastables. The product of the diffusion coefficient and the helium atom density at 300°K is $1{\cdot}5\times10^{19}$ (cm²/sec)(atom/cm³) for the atomic metastables and $1{\cdot}0\times10^{19}$(cm²/sec)(atom/cm³) for the molecular metastable. The cross-sections for the destruction of the singlet atomic metastables are 3×10^{-14} cm² and 3×10^{-20} cm² for collisions with thermal (300°K) electrons and neutral atoms, respectively. The three-body combination coefficient for the conversion of triplet atomic metastables into molecular metastables is $2{\cdot}5\times10^{-34}$ $cm^6.atom^{-2}.sec^{-1}$ at 300°K. A.

539.153 : 537.13

9024. On the spectrum of positronium in external fields. V. N. TSYTOVICH. *Zh. éksper. teor. Fiz.*, **28**, *No.* 6, 664–78 (1955) In Russian.

The energies are found from a two-body equation of the Breit type valid to order v^2/c^2. This 16-component equation is reduced to an equation on the large components. Energies in weak and strong magnetic and electric fields and probabilities of annihilation in external fields are evaluated. G. E. BROWN

539.153.4

9025. Comparison of the approximate solutions for free neutral atoms. T. TIETZ. Letter in *J. chem. Phys.*, **23**, *No.* 6, 1167 (*June*, 1955).

The value of the variational integral of Umeda [Abstr. 9522 (1954)], which is a minimum for the exact solution of the Thomas–Fermi equation $\Phi'' = x^{-\frac{1}{2}}\Phi^{\frac{3}{2}}$, is used as a measure of the accuracy of approximations of the type $(1 + ax)^{-\alpha}$. These solutions are compared with those of Sommerfeld, Bush and Caldwell, and Baker. W. J. SWIATECKI

539.153.4

9026. Study of a family of approximate wave-functions for the helium atom. G. MUNSCHY. *J. Phys. Radium*, **16**, *No.* 6, 473–9 (*June*, 1955) In French.

The method of approximation which had previously been applied to the ground state of helium [Abstr. 7750 (1950), 780 (1952)] has been applied to the states with $n = 2$. The calculations of the energy levels of the excited states were less satisfactory than those for the ground state. However, these wave-functions gave better results than those obtained from hydrogenic wave-functions and an effective charge parameter. J. HUGHES

539.153.4

9027. Solutions of the temperature-perturbed Thomas–Fermi equation. J. J. GILVARRY AND G. H. PEEBLES. *Phys. Rev.*, **99**, *No.* 2, 550–2 (*July* 15, 1955).

Previous numerical results [Abstr. 760, 1127 (1955)] are extended by using an analytical solution of the temperature-perturbed Thomas–Fermi equation to obtain boundary and initial parameters corresponding to seven neutral-atom zero-temperature solutions given by Slater and Krutter. Fitted functions given previously for the solution parameters in terms of the unperturbed atom radius are revised to include the new data, to obtain a considerable extension in directly-fitted range. Effects of the temperature perturbation on the equation of state, the internal energy, and parameters related to the equation of state are shown graphically for the extended range. A.

539.154.3

9028. Ratio of the magnetic moments of the stable gallium isotopes. M. RICE AND R. V. POUND. Letter in *Phys. Rev.*, **99**, *No.* 3, 1036–7 (*Aug.* 1, 1955).

An accurate experimental determination of $\mu(Ga^{71})\mu(Ga^{69})$. G. E. BROWN

539.155.2 : 535.417

Interferometer for analysing mixtures of hydrogen isotopes. *See Abstr.* 8657

539.155.4

9029. The mass difference $^{41}A - {}^{41}K$. J. C. KLUYVER AND C. VAN DER LEUN. *Physica*, **21**, *No.* 7, 604 (*July*, 1955).

An accurate measurement of the energy of the γ-ray following the β-emission of A^{41} was made with scintillation counters. The result was $E = 1{\cdot}298 \pm$

0·010 MeV, combining this with the known energy of the β-ray, the mass difference was found to be 2·543 ± 0·011 MeV. J. HUGHES

RADIOACTIVITY . α-, β- AND γ-RAYS 539.16

539.16.08

9030. A study of the application of coincidence methods to the absolute calibration of Na^{24}, Co^{60} and Sc^{46}. S. VUCCINO. *J. Phys. Radium*, **16**, *No.* 6, 462–8 (*June*, 1955) In French.

Two methods of measurement were employed: of β–γ-coincidences using a thin-window β-particle counter and a γ-scintillation counter; and of γ–γ coincidences using two scintillation counters. A. O. STANESBY

539.16.08

9031. Radon intensity in uranium mines by the method of collection on carbon. CADUDAL. *J. Phys. Radium*, **16**, *No.* 6, 479–82 (*June*, 1955) In French.

A technique of adsorption on activated charcoal followed by a measurement of the emission of RaC is described. It is possible to measure 10^{-12} c/l and the accuracy is of the order of 7%. The apparatus is light, robust and easy to operate. J. M. HOUGH

539.16.08

9032. International comparisons of the Canadian primary radium standard. W. S. MICHEL AND G. N. WHYTE. *Canad. J. Phys.*, **33**, *No.* 9, 521–8 (*Sept.*, 1955).

The content in milligrams of radium element of the Canadian primary radium standard was measured relative to the certified weight of a primary standard of the United States by an ionization method. The problem of correcting for differences in the attenuation of the γ-radiation in the body of each source is important, since the standards differ greatly in shape; a method of making this correction is described. Other intercomparisons involving the Canadian standard are discussed, and a mean value for the content of the standard is derived from these comparisons. The agreement between this and the certified value is satisfactory. A.

539.16.08 : 537.542

Continuous flow monitoring of tritium in air. *See Abstr.* 8854

539.16.08 : 539.167.3 : 537.542

Pulse analysis—a discussion of effects important in the radiochemistry of the heavy elements. *See Abstr.* 8863

539.163

9033. Rhenium 190. A. H. W. ATEN, JR AND G. D. DE FEYFER. Letter in *Physica*, **21**, *No.* 6, 543 (*June*, 1955).

A β^--emitting Re isotope ($E_{\beta max} = 1·7 \pm 0·3$ MeV, $\tau_{\frac{1}{2}} = 2·8 \pm 0·5$ min) was prepared by the irradiation of Os with fast neutrons or 26 MeV deuterons; the isotope also emits at least 3 γ-rays; the mass-number may be 190. A. O. STANESBY

539.163

9034. Relative intensities of the radiations from Hf^{175}. A. O. BURFORD, J. F. PERKINS AND S. K. HAYNES. *Phys. Rev.*, **99**, *No.* 1, 3–6 (*July* 1, 1955).

The intensities of the electronic and electromagnetic radiations of Hf^{175} have been measured with a magnetic-lens spectrometer. The existence of transitions of 89·1, 113·4, 228, 318, 342·3 and 431 keV was confirmed. For the 89·1 keV transition $\alpha_K = 3·5^{+1·5}_{-2·5}$, $\alpha_K/\alpha_L = 6·0 \pm 1$, $\alpha_L/\alpha_N = 3·5 \pm 0·9$, and the transition is predominantly $M1$. For the 228 keV transition $\alpha_K/\alpha_{L+M} = 2·0 \pm 0·5$ and the transition is of the type $E2$. For the 342·3 keV transition $\alpha_K/\alpha_{L+M} = 4·94 \pm 0·5$, and the transition is a mixture of $M1$ and $E2$. A decay scheme is given in which the ground state of Lu^{175} is characterized as $\Omega = 7/2$, $I = 7/2$, parity even; the 113·4 keV state is the first rotational excited state with $\Omega = 7/2$, $I = 9/2$, parity even; the 342·3 keV state is a single-particle excited state with $\Omega = 5/2$, $I = 5/2$, parity even; and the 431 keV state is the first rotational excitation of the 342·3 keV state with $\Omega = 5/2$, $I = 7/2$, parity even. A.

539.163

9035. The decay of cobalt 57. H. R. LEMMER, O. J. A. SEGAERT AND M. A. GRACE. *Proc. Phys. Soc. A*, **68**, *Pt* 8, 701–8 (*Aug.*, 1955).

The X- and γ-radiations excited during the decay of Co^{57} have been investigated with scintillation and proportional counters. These measurements showed that the 14·4 ± 0·1 keV γ-ray follows the 123 keV γ-ray with a half-life of $1·0 \pm 0·1 \times 10^{-7}$ sec and that its internal conversion coefficient (α_{total}) is 15 ± 1. No evidence for β^+-emission with an intensity greater than 1/1 300 per disintegration was found and upper limits of about 14% were set on the number of disintegrations proceeding directly to the ground and first excited states of Fe^{57}. Spin and parity assignments are suggested. A.

539.163

9036. The decay of RaD and the 46·5 keV excited state of RaE. G. M. LEWIS. *Proc. Phys. Soc. A*, **68**, *Pt* 8, 735–40 (*Aug.*, 1955).

The lifetime of the 46·5 keV excited state following β-decay of RaD has been shown, by delayed coincidence methods, to be less than 3×10^{-9} sec; this specifies the 46·5 keV transition to be a dipole one. An investigation of the scintillations from an activated sodium iodide crystal containing RaD has determined the complete integrated spectrum of RaD, free from effects of source absorption. This spectrum consists in the main of a single peak, and indicates directly that at least 90% of the disintegrations involve soft β-decay to the 46·5 keV excited state followed by rapid de-excitation. Less than 5% of the disintegrations pass through metastable states. The β-decay is briefly discussed. A.

539.163 : 539.172.13

9037. An attempt to discover nuclei of H^4 among the products of spallation of carbon by protons of energy 300 MeV. A. A. REUT, S. M. KORENCHENKO, V. V. YUR'EV AND B. M. PONTEKORVO [PONTECORVO]. *Dokl. Akad. Nauk SSSR*, **102**, *No.* 4, 723–5 (1955) In Russian.

This paper is based on work done in 1951–52 at the Institute of Nuclear Problems. Arguments are

given to show that a β-active H^4 nucleus can exist if the He^4 nucleus has an excited state of excitation energy less than about 20 MeV. There is some indication that such a state exists with energy about 21 MeV. If the reaction $H^4 \rightarrow He^4 + \beta^- + \gamma$ is permitted, the decay half-life of H^4 might be a few milliseconds. A search was made by placing a telescope of three proportional counters in the synchro-cyclotron chamber, near a carbon target. The presence of subsidiary impulses was avoided by removing the accelerating potential. The target was irradiated by protons of energy 300 or 430 MeV, and the number of triple coincidences with various delay times was measured. If β-particles of energy greater than 12 MeV were emitted, they would be recorded by the apparatus. Cross-sections not greater than a few microbarns were found for the reactions concerned. It is concluded that a β-active H^4 nucleus probably does not exist, since other experiments have failed to reveal such a nucleus of decay half-life 0·03 to 120 sec. J. B. SYKES

539.163.1

9038. A short-lived ruthenium isotope. A. H. W. ATEN, JR AND T. DE VRIES-HAMERLING. Letter in *Physica*, **21**, *No.* 6, 544 (*June*, 1955).

A short-lived Ru activity ($\tau_{\frac{1}{2}} \sim 52$ sec) was obtained from the irradiation of Mo by 52 MeV He^{2+} ions. A. O. STANESBY

539.163.1

9039. The half life of the 145 keV level of 141 praseodymium. H. DE WAARD AND T. R. GERHOLM. Letter in *Physica*, **21**, *No.* 7, 599–600 (*July*, 1955).

Delayed coincidence measurements gave a value $(19 \pm 2) \times 10^{-10}$ sec. J. J. WILKINS

539.163.2

9040. Investigation of 15 min antimony using [γ-γ and β-γ] coincidence-spectrographs with dual energy dispersion. P. STÄHELIN, D. MAEDER AND M. POCHON. *Z. Phys.*, **140**, *No.* 5, 498–503 (1955) In German.

A new coincidence spectrometer which records simultaneously the scintillation amplitudes from two crystals was used in the investigation of one of the two 16 min activities of Sb. The resultant decay scheme of the γ-emitting isotope leads to its unique assignment to $A = 116$. A. O. STANESBY

539.163.2

9041. Disintegration of $_{62}Sm^{153}$. N. MARTY. *J. Phys. Radium*, **16**, *No.* 6, 458–61 (*June*, 1955) In French.

The β-spectrum consists of 3 components with $E_{\beta max} = 820 \pm 10(20)$, $720 \pm 15(40)$ and 650 ± 15 keV (40%). The conversion coeffs. of the 103 keV γ-ray were measured: $\alpha_K = 1{\cdot}2 \pm 0{\cdot}1$, $K/L = 6{\cdot}2 \pm 0{\cdot}3$, $L/M = 4{\cdot}5$; γ-rays of 545 and 172 keV with intensities $< 1\%$ were confirmed and conversion lines of a weak 84 keV γ-ray were found. A coherent disintegration scheme is given. A. O. STANESBY

539.163.2

9042. Nuclide 99^{254}. B. G. HARVEY, S. G. THOMPSON, G. R. CHOPPIN AND A. GHIORSO. Letter in *Phys. Rev.*, **99**, *No.* 1, 337 (*July* 1, 1955).

A long-lived, α-active isomer of nuclide 99^{254}, of half-life >2 years, has been found. The known 36-hour, β-active isomer is probably the metastable state, and has been found to exhibit 0·1% electron-capture branching to Cf^{254}. J. J. WILKINS

539.163.2

9043. Electron capture in the decay of sodium 22. R. A. ALLEN, W. E. BURCHAM, K. F. CHACKETT, G. L. MUNDAY AND P. REASBECK. *Proc. Phys. Soc. A*, **68**, *Pt* 8, 681–5 (*Aug.*, 1955).

The fraction of electron capture transitions in the decay of Na^{22} has been found by comparing the rate of evolution of Ne^{22} from a source of Na^{22} with the rate of emission of positrons. The ratio of electron capture to positron transitions is found to be $0{\cdot}122 \pm 0{\cdot}010$; a possible systematic error in the Ne^{22} determination would increase this figure. A.

539.163.2

9044. New isotope manganese-53. J. R. WILKINSON AND R. K. SHELINE. *Phys. Rev.*, **99**, *No.* 3, 752–4 (*Aug.* 1, 1955).

Manganese-53 has been produced by the nuclear reaction $Cr^{53}(p, n)Mn^{53}$ in the bombardment of enriched Cr^{53} for a period of 8 hours with 9·5 MeV protons. Measurements of the decay and absorption data indicate that this nuclide is an orbital electron capturing activity without γ-rays or positrons. With the assumption that the cross-section for the reactions $Cr^{53}(p, n)Mn^{53}$ and $Cr^{54}(p, n)Mn^{54}$ are the same, it is possible to calculate an approximate half-life of 140 years for this nuclide. These data together with those from previous measurements on the energy levels of Cr^{53} indicate that Mn^{53} probably decays from an $F_{5/2}$ ground state to a $p_{3/2}$ Cr^{53} ground state in an l-forbidden transition with a relatively high log ft value. A.

539.163.2

9045. Long-lived isomer of Al^{26}. T. H. HANDLEY AND W. S. LYON. *Phys. Rev.*, **99**, *No.* 3, 755–6 (*Aug.* 1, 1955).

Long-lived Al^{26} has been chemically purified from aluminium targets used in the 86 in. cyclotron. The main decay observed is through a $1{\cdot}30 \pm 0{\cdot}15$ MeV positron in coincidence with a 1·82 MeV γ-ray. In addition, γ-rays of 0·717 MeV and 2·91 MeV have been found. A.

539.163.2

9046. Metastable states of Re^{180}, Ir^{191}, Au^{193}, Pb^{201}, and Pb^{203}. V. K. FISCHER. *Phys. Rev.*, **99**, *No.* 3, 764–70 (*Aug.* 1, 1955).

Ten elements of atomic number between 60 and 82 have been bombarded with 31·5 MeV protons and examined for activities with half-lives between 0·5 and 200 sec. None were observed in Sm, Ho, Tm, Lu and Ta. Those produced in W, Ir, Pt, Au and Tl were investigated with scintillation and proportional counters. Isotope assignments were made on the basis of excitation function studies. Observed were Re^{180m} (145 sec), Ir^{141m} (4·9 sec), Au^{193m} (3·9 sec), Au^{195m} (31 sec), Au^{197m} (7·4 sec), Pb^{201m} (60 sec) and Pb^{203m} (6·7 sec). Decay schemes are proposed and some regularities are discussed. A.

539.164

9047. The study of nuclear evaporation in Ag and Pt by means of sandwich emulsions. C. ZANGGER AND J. ROSSEL. *Helv. phys. Acta*, **28**, *No.* 4, 349–52 (1955) In French.

Using sandwich emulsions containing foils of Ag

and Pt the energy spectra of α's from these metals have been measured. They are found to exhibit excesses of particles at both low and high energies. These can be explained by fission following the normal nuclear evaporation as suggested by Sussmann [Abstr. 2702 (1954)]. A. J. EGGINTON

539.164.2

9048. A generalization of the Bateman–Poisson law for time correlated alpha-emission. H. LINDEMAN. *Physica*, **21,** *No.* 7, 589–95 (*July*, 1955).

A derivation is given of a probability law, which replaces the Bateman–Poisson law in cases of time correlated α-emission, as occurs for example for some members of the thorium series. This probability law has a structure similar to the Bateman–Poisson law, but differs from it by a certain factor B which depends on the size of the counting interval and on the decay constants of the radioactive daughter substances involved in the time correlated emission. The law is used to generalize Adams's calculations of the probability function for the α-emission in the entire thorium series. The theoretical results are compared with experimental data and good agreement is found. The derived law may be applied to any chain of events where similar time correlations exist. A.

539.164.74

9049. Elastic scattering of 40-MeV alpha particles from heavy elements. H. E. WEGNER, R. M. EISBERG AND G. IGO. *Phys. Rev.*, **99,** *No.* 3, 825–33 (*Aug.* 1, 1955).

Angular distributions have been measured for the elastic scattering of 40 MeV α-particles from Ta, Au, Pb and Th in the angular range 21 to 155°. If the ratios of the measured cross-sections to the Coulomb cross-section are assumed equal to 1·0 at small angles, they increase slightly with increasing angle, and in the vicinity of 30° decrease exponentially with increasing angle to values less than 0·001. These data are compared with the semiclassical, strong absorption model of Blair and with the recent model of Ford and Wheeler. A.

539.164.74 : 539.172.11

9050. Elastic scattering of 48·2 MeV alpha particles. R. E. ELLIS AND L. SCHECTER. Letter in *Phys. Rev.*, **99,** *No.* 3, 1044–5 (*Aug.* 1, 1955).

Measurements were made on Au and Ag targets at angles between 7° and 135° using a proportional counter telescope. At angles greater than 25° these show departures from Coulomb scattering by factors of 10^3–10^4 which are attributed to the effect of nuclear interactions. M. A. GRACE

539.165

9051. The complex beta transitions of Na^{25} and Al^{25}. D. MAEDER AND P. STAEHELIN. *Helv. phys. Acta*, **28,** *No.* 2–3, 193–226 (1955) In German.

Scintillation counter techniques were used to investigate radiations of Na^{25} produced by betatron irradiation of Mg. The end point was found to be $4·0 \pm 0·2$ MeV. for the β-transition to the ground state of Mg^{25}. Four γ-rays were found with energies, 384 ± 10, 576 ± 10, 978 ± 10 and $1\,603 \pm 20$ keV. Coincidence measurements showed that 65 3·5, 25 and 6·5% of the β-transitions lead to the ground state and to the first 3 excited states of Mg^{25}. From the *ft* values it was deduced that Na^{25} has spin $3/2^+$. The short-lived activities of Al^{25+26} were produced by proton irradiation of Mg. A weak γ-ray of $1·58 \pm 0·03$ MeV was found, and the $\gamma : \beta^+$ ratio indicated a normal allowed transition from Al^{25} to the 1·6 MeV level in Mg^{25}, which must be either a $3/2^+$ or a $5/2^+$ state. J. HUGHES

539.165

9052. On an abnormal β-radiation from metallic uranium. G. VACCA AND L. PERREAU. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 25, 2404–5 (*June* 20, 1955) In French.

Abnormally intense β-radiation has been observed from metallic uranium following thermal treatment. The phenomenon is attributed to a surface concentration of UX_1. J. J. WILKINS

539.165

9053. On the β^--decay of ^{171}Tm. A. BISI, S. TERRANI AND L. ZAPPA. Letter in *Nuovo Cimento* (*Ser.* 10) **2,** *No.* 1, 172 (*July*, 1955).

The end point of the β-spectrum was found to be 103 ± 2 keV, the spectrum showing no appreciable departure from the allowed shape. The log *ft* value is 6·4. J. HUGHES

539.165.2

9054. Combinations of interaction terms in the theory of β-decay. D. C. PEASLEE. *Z. Phys.*, **141,** *No.* 3, 399–402 (1955) In German.

Given linear combinations of the five invariant forms occurring in the theory are taken as basis vectors for the representation of the three-dimensional permutation group. With their use, the decay parameters of μ-mesons take a particularly simple form and the usual invariance conditions lead immediately to $(S - T + P)$ being the only possible combination of the five invariants. L. PINCHERLE

539.165.2 : 539.152.1

9055. Beta energetics and nuclear shell structure. S. N. GHOSHAL AND A. N. SAXENA. *Indian J. Phys.*, **29,** *No.* 2, 81–94 (*Feb.*, 1955).

The occurrence of discontinuities in the binding energies of the last neutron or last proton in nuclei at magic numbers of neutrons or protons causes discontinuities to appear in the β^--disintegration energies $E_\beta(A, Z)$ of radioactive nuclei. The difference $\epsilon_\beta(A, Z)$ between the observed values of $E_\beta(A, Z)$ and the values calculated from the Fermi–Weizsäcker mass formula for a series of isotopes (Z = constant) have been plotted against the neutron number N in these nuclei. Discontinuities are found to appear at $N = 50$, 82 and 126. In order to show the nature of variation of the pairing energy term in the β^--disintegration energy, the observed $E_\beta(A, Z)$ values have been plotted against Z for isobaric sequences for various odd values of A. The pairing energy terms have been derived from the $\epsilon_\beta(A, Z)$ values of these isobaric sequences and the corresponding values of B_A, the slope of the isobaric line without the pairing energy term, have been deduced. The departure of the B_A values from the calculated values are discussed. The effect of shell crossing on these isobaric lines is also discussed. Evidences for the occurrence of discontinuity in the pairing energy term for even A nuclei have been observed. A.

539.165.2 : 539.152.1

9056. Beta-disintegration and nuclear structure. Nucleon–lepton interaction, selection rules and the shell-model. R. NATAF. *Cahiers de Phys.*, *No.* 56, 5–28 (*April*, 1955) In French.

A theoretical discussion of the interrelation between β-disintegration theory and nuclear structure theory, and the deductions which may be made from them about the nuclear interactions. A. O. STANESBY

539.166

9057. Measurement of the intensities of the high energy γ-rays from RaC′. G. BACKENSTOSS AND K. WOHLLEBEN. *Z. Naturforsch.*, **10a**, *No.* 5, 384–6 (1955) In German.

The relative intensities of the 1·76, 2·20 and 2·42 MeV γ-rays from RaC′ were determined by means of a scintillation spectrometer to be 3·22 : 1·00 : 0·48. By comparison with the known number of γ-ray quanta from ThC″ the absolute intensity of the 2·42 MeV γ-ray has been estimated to be $(8{\cdot}9 \pm 0{\cdot}5)10^5$/mgRa sec. D. J. PROWSE

539.166

9058. Cascade gamma rays from $_{84}Po^{214}$ (RaC′). R. E. ROWLAND. *Phys. Rev.*, **99**, *No.* 3, 757–9 (*Aug.* 1, 1955).

Seven γ-cascades of $_{84}Po^{214}$ have been identified by means of coincidence scintillation spectrometry: γ-rays of energy 0·77, 0·93, 1·12, 1·24, 1·38, 1·52 and 1·85 MeV appear in coincidence with the 0·607 MeV photon transition to the ground state. The existence of a weak β-transition to the 0·607 MeV level was also verified. Four other γ-rays, of energy 0·85, 1·77, 2·20 and 2·40 MeV, appear as direct transitions to the ground state. Both γ–γ and β–γ coincidences were employed to verify the suggested energy level scheme. A.

539.166 : 539.152.1

9059. Thermal neutron capture γ-rays and the structure of the atomic nuclei. L. V. GROSHEV. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 4, 651–4 (1955) In Russian.

Discusses the results of Kinsey and Bartholomew [Abstr. 3032 (1951) and 5249 (1950)], by introducing a function $(\alpha_{\frac{1}{2}})$ equal to the percentage of the nuclear excitation energy, which is obtained in the form of γ-photons whose energy exceeds half of the neutron bonding energy in the nucleus. This function was calculated for all 45 elements investigated, and plotted against Z and N. The curves obtained show maxima for $Z = 14, 20, 28, 82$ and $N = 14, 20, 28, 50, 82, 126$. With only two exceptions, the points lying far from the (Z and N) curves correspond to the above (N and Z) magic numbers. It is assumed that, in the nuclei near to the "magic" ones, it is predominantly the photons with $h\nu > \frac{1}{2}\varepsilon_{bond}$ that are formed as a result of the excited state caused by the capture of thermal neutrons. Certain regularities in the nature of the capture γ-ray spectra are related to the fact that the density of energy levels in the nucleus is much smaller in the neighbourhood of the (Z and N) "magic" numbers than it is far from these numbers. F. LACHMAN

539.166 : 539.172.4

9060. Gamma-rays from inelastic scattering of D-T neutrons from carbon 12 and oxygen 16. L. E. BEGHIAN, D. HICKS AND B. MILMAN. Letter in *Phil. Mag.*, **46**, 924–6 (*Aug.*, 1955).

Scintillation spectrometer measurements revealed only the 4·43 MeV rays from C^{12} and the 6·13 MeV ray from O^{16}. J. J. WILKINS

539.166.08 : 612.014.482

Assay of γ-radiation from the human body. *See Abstr.* 9313

539.166.835

9061. Absolute pair creation cross-section of lead for gamma rays from Co^{60} and Na^{24}, and pair production of RaC gamma radiation in lead. P. SCHMID AND P. HUBER. *Helv. phys. Acta*, **28**, *No.* 4, 369–88 (1955) In German.

Using the method of detecting annihilation coincidences, absolute cross-sections in lead for the creation of electron pairs by γ-rays have been determined at 1·3 and 2·75 MeV. The sum of the cross-sections for both γ-rays of Co^{60} is found to be $0{\cdot}274 \pm 0{\cdot}008$ barn. This value is in good agreement with earlier measurements and is 109% higher than the value calculated from the Born approximation. The value determined for the pair-production cross-section in lead at 2·75 MeV is $3{\cdot}18 \pm 0{\cdot}12$ barn which is 12% higher than calculated from the Born approximation. This agrees with the numerical calculations of Jaeger and Hulme within the limits of error. In addition, the pair production in lead by γ-rays of RaC has been observed. It can be described by the assumption that 0·480 quanta of energy 1·8 MeV and pair-production cross-section $1{\cdot}25 \pm 0{\cdot}05$ barn are emitted per α-ray of Ra. A.

539.166.835

9062. Temperature effects in the annihilation of positrons. R. T. WAGNER AND F. L. HEREFORD. Letter in *Phys. Rev.*, **99**, *No.* 2, 593–4 (*July* 15, 1955).

The three-photon rate is measured as a function of temperature. G. E. BROWN

539.166.835

9063. Measurement of electron momentum by positron annihilation. G. LANG, S. DEBENEDETTI AND R. SMOLUCHOWSKI. Letter in *Phys. Rev.*, **99**, *No.* 2, 596–8 (*July* 15, 1955).

The angular distribution of γ-rays from two-quantum positron annihilations in various metals is measured and provides a means of investigating electronic states in solids. The momentum distribution of the annihilating pairs corresponds closely to a Fermi gas. C. A. HOGARTH

539.166.835

9064. Angular correlation of photons from positron annihilation in solids. A. T. STEWART. Letter in *Phys. Rev.*, **99**, *No.* 2, 594–5 (*July* 15, 1955).

Measurements [Abstr. 5618 (1955)] have been continued with higher resolution and show, among other things, a component of high momentum from heavier solids and a difference in pattern of annihilation in metals from that in amorphous non-conducting materials. G. E. BROWN

NUCLEAR REACTIONS 539.17

539.172 : 539.18

9065. High-energy nuclear physics. W. E. Burcham. *Nature* [*London*] **176,** 371–3 (*Aug.* 27, 1955).

Brief report of the Physical Society's meeting at Liverpool, July 5–6.

539.172

9066. Fission of the uranium atom by the action of slow π^--mesons and particles of high energy. G. E. Belovitskiĭ, T. A. Romanova, L. V. Sukhov and I. M. Frank. Letter in *Zh. éksper. teor. Fiz.*, **28,** *No.* 6, 729–32 (1955) In Russian.

Fission from π^--mesons, neutrons with energy up to 460 MeV and γ-rays up to 250 MeV is studied in photographic plates impregnated with uranium. From 3000 π^--mesons stopped in the emulsions, 96 cases of fission, 81 with two splinters and 15 with three, are observed (the plates were sensitive only to protons of energy <30 MeV). Probability of fission of U is estimated to be $\sim 50\%$. With neutrons, 309 fissions, 69 accompanied by one or more long-range charged particles, were observed. For γ-rays, the numbers were 2066 and 45, respectively. On radiation with γ-rays of energy up to 30 MeV, 117 fissions with no singly charged particles, and 1 with a long-range α-particle, are observed. Remarks are made on the angular distributions of the protons and α-particles, for all of the above cases. G. E. BROWN

539.172

Nuclear reactions due to cosmic rays. *See also under* "Cosmic rays." Decimal classification 537.591.8

539.172

9067. Fission of heavy nuclei by slow π^--mesons. N. A. Perfilov and N. S. Ivanova. Letter in *Zh. éksper. teor. Fiz.*, **28,** *No.* 6, 732–4 (1955) In Russian.

Photographic plates bathed in solutions containing U, Pb and W were irradiated with slow π^--mesons. Probability of fission was found to be very small for W. For U, 356 cases of fission were found; it is estimated that fission takes place in $\sim 50\%$ of the cases of capture. The number of fission fragments shows a distinct maximum as a function of range. The mean range is the same as in fission of slow neutrons, showing that the π^--rest-mass is not transformed into kinetic energy of the fragments. In many cases protons are given off, isotropically; their energy distribution is measured. A simple model for the fission mechanism is proposed. G. E. BROWN

539.172

9068. Energy of electrons or photons from their cascade showers in copper. W. E. Hazen. *Phys. Rev.*, **99,** *No.* 3, 911–14 (*Aug.* 1, 1955).

Cloud-chamber photographs have been used for the study of cascade showers in copper plates produced by electrons of known momentum. The best constant for obtaining primary energy from the total number of track segments is given. The uncertainty in primary energy as determined by this method is found from the experimentally observed distributions. The results are applied to the interpretation of heavy *S*-particle observations. A.

539.172.13

9069. Interaction of protons with tritium and excited states of He^4. N. A. Vlasov, S. P. Kalinin, A. A. Ogloblin, L. N. Samoĭlov, V. A. Sidorov and V. I. Chuev. *Zh. éksper. teor. Fiz.*, **28,** *No.* 6, 639–50 (1955) In Russian.

The reactions $T(p,n)He^3$ and $T(p,\gamma)He^4$ are studied with protons, from a cyclotron, of primary energy $7{\cdot}3 \pm 0{\cdot}1$ MeV slowed down to the desired energy by slabs of Pb [see Abstr. 8847 (1955)]. For the $T(p,n)He^3$ reaction, the cross-section at 0° and total cross-section are measured as functions of energy from 1–7 MeV and angular distributions are given at various energies. The cross-section has a broad maximum at $E_p = 3$ MeV. Results indicate that the excited level should be classified 2^- [Abstr. 1178 (1955)]. The curve for $T(p,\gamma)He^4$ shows no resonance features and seems to proceed by way of the 1^- level by dipole radiation to the ground 0^+. The angular distribution of γ-rays supports this. However, a small non-dipole term in the angular distribution is observed, indicating another intermediate state.

G. E. BROWN

539.172.13

9070. The cross section for the reaction $^{10}B(p\alpha)^7Be$ at proton energies below 200 keV. G. G. Bach and D. J. Livesey. *Phil. Mag.*, **46,** 824–30 (*Aug.*, 1955).

This was measured absolutely for proton energies of about 200 keV using magnetic analysis. Values of $0{\cdot}92 \pm 0{\cdot}13$, $0{\cdot}66 \pm 0{\cdot}09$ and $0{\cdot}29 \pm 0{\cdot}04$ mb were found for proton energies of 205, 200 and 180 keV respectively. Cross-sections relative to these values were obtained for proton energies down to 70 keV. A.

539.172.13

9071. Capture radiation and neutrons from the bombardment of C^{14} with protons. G. A. Bartholomew, F. Brown, H. E. Gove, A. E. Litherland and E. B. Paul. *Canad. J. Phys.*, **33,** *No.* 8, 441–56 (*Aug.*, 1955).

The yield and angular distribution of ground-state γ-rays and of neutrons resulting from the proton bombardment of C^{14} have been studied for proton energies from 0·2 to 2·5 MeV. Assignments of spin and parity are made to most of the resonances observed in this range. A single-particle proton state which may have isotopic spin 3/2 has been observed. The interference of this state, which has spin 1/2+, with a neighbouring state of the same spin and parity is observed in the total yield of the ground-state γ-ray. Three states below the neutron threshold which have been observed previously in the $N^{14}(d,p)N^{15}$ reaction are also observed in the $C^{14}(p,\gamma)N^{15}$ reaction. The $N^{14}(n,p)C^{14}$ cross-section at thermal energies can be accounted for by a resonance observed in this experiment, but another resonance below the neutron threshold must be assumed to account for the thermal (n,n) and (n,γ) cross-sections. A.

539.172.13

9072. Resonant capture of protons by fluorine in the energy range 0·5 to 2·2 MeV. S. E. Hunt and K. Firth. *Phys. Rev.*, **99,** *No.* 3, 786–8 (*Aug.* 1, 1955).

The energy of a proton beam from a pressurized electrostatic generator was measured absolutely by

means of an electrostatic analyser, and used to irradiate thin targets containing fluorine. The γ-ray yield was observed as a function of proton energy and the energies for resonant proton capture were determined to an accuracy of one part in a thousand in most cases. The width of each resonance at half-maximum yield was also measured. A.

539.172.13

9073. Attenuation cross sections for 860-MeV protons. F. F. Chen, C. P. Leavitt and A. M. Shapiro. *Phys. Rev.*, **99**, *No.* 3, 857–71 (*Aug.* 1, 1955).

Integral angular distributions of 860 MeV protons scattered by Be, C, Al, Cu, Sn and Pb nuclei have been measured in a transmission experiment in which the half-angle subtended at the absorber by the detector was varied from 1·5 to 20°. A counter telescope technique employing plastic scintillation counters and a fast-coincidence circuit was used. From the cross-sections measured with poor geometry it is possible to deduce the inelastic cross-section for the heavy elements and, less unambiguously, also for the light elements. Agreement with 1·4 BeV neutron data from a concurrent experiment is good. Total cross-sections could not be obtained for the heavy elements because of Coulomb effects, but for the light elements rough estimates could be made. The data are consistent with an interpretation in terms of the "optical" model of the nucleus with constant nuclear density. If the nucleon–nucleon cross-section at this energy is taken to be 45 mb, these measurements yield a nuclear absorption constant K of $0{\cdot}56\times10^{13}\,\mathrm{cm}^{-1}$ and a nuclear radius of the form $R=(1{\cdot}25\pm0{\cdot}02)A^{\frac{1}{3}}\times10^{-13}$ cm. A.

539.172.13

9074. Asymmetry in high-energy p–n–p double charge-exchange scattering. H. Bradner and R. E. Donaldson. *Phys. Rev.*, **99**, *No.* 3, 890–2 (*Aug.* 1, 1955).

Asymmetries have been observed in double charge-exchange p–n–p scattering from carbon and tantalum. High-energy protons striking a first target gave charge-exchange neutrons. These neutrons were collimated and allowed to strike a second target. The final proton fluxes to the right and left were then counted. The asymmetries are zero at small scattering angles, and increase with angle up to 45° in the laboratory system. The maximum asymmetry observed was $10{\cdot}4\pm2{\cdot}1\%$ for carbon with the first and second scattering angles equal to 45° (lab.). Evidence is given for a large n–p charge-exchange polarization from carbon bombarded with 170 MeV neutrons. A.

539.172.13

9075. Asymmetry in p–n and p–p scattering from targets bombarded with 285-MeV polarized protons. R. E. Donaldson and H. Bradner. *Phys. Rev.*, **99**, *No.* 3, 892–5 (*Aug.* 1, 1955).

Asymmetries in neutron and proton production have been observed in the quasi-elastic scattering of 285 MeV, $65\pm4\%$ polarized protons by carbon, lithium and beryllium targets. The neutrons and protons were counted in coincidence with the associated scattered protons. The quasi-elastic neutron data are not antisymmetric about 90° cm. The proton asymmetries are much smaller than the asymmetries from a free hydrogen target. A.

539.172.13

9076. The gamma radiation from the reaction $D(p,\gamma)^3$He. G. M. Griffiths and J. B. Warren. *Proc. Phys. Soc. A*, **68**, *Pt* 9, 781–92 (*Sept.*, 1955).

Using a scintillation counter for the measurement of the γ-radiation, the Q-value of the reaction $D(p,\gamma)He^3$ was found to be $5{\cdot}50\pm0{\cdot}03$ MeV. The Doppler shift has been measured. The angular distribution was found to be nearly a pure $\sin^2\theta$ pattern at all proton bombarding energies from 0·5 to 2 MeV but evidence has been obtained for a small isotropic component. Neutrons were detected, arising, via the $D(d,n)He^3$ reaction, from the knock-on deuterons. The relative yield curve has been measured with a thin target and is in accord with the formula given by Fowler and his co-workers. An approximate measurement of the absolute cross-section at $E_p=1{\cdot}0$ MeV gave $4\times10^{-30}\,\mathrm{cm}^2\pm50\%$. A.

539.172.13 : 539.18

9077. A study of the nuclear disintegrations produced by 950 MeV protons. W. O. Lock, P. V. March and R. McKeague. *Proc. Roy. Soc. A*, **231**, 368–78 (*Sept.* 6, 1955).

Nuclear disintegrations produced in the heavy nuclei of Ilford G5 photographic emulsions by 950 MeV protons have been analysed in detail. The characteristics of the disintegrations observed can be explained in terms of a simple model which assumes that a substantial fraction of the π-mesons created is re-absorbed in the parent nucleus and that the energy of these mesons contributes mainly to the excitation energy of the residual nucleus. A.

539.172.13 : 778.34

9078. Some experimental results obtained with the aid of photographic plates bombarded with nucleons of high energy. J. Combe. *J. Phys. Radium*, **16**, *No.* 6, 445–57 (*June*, 1955) In French.

Some results on a study of stars produced in emulsion by 340 MeV protons are given. The energy distributions and angular distributions are given for prongs caused by particles of energy >30 MeV. Results are presented separately for the light and heavy nuclei. Differences appear which are explained by an internal α-particle structure in the light nuclei and a nuclear gas structure in the heavy nuclei. A grain-density v. energy curve was drawn for each plate using p–p collisions to give protons of varying energy. A method is given for the accurate determination of emulsion shrinkage. D. J. Prowse

539.172.13

9079. Interaction of fast deuterons with nuclei. E. L. Feĭnberg. *Zh. éksper. teor. Fiz.*, **29**, *No.* 1(7), 115–20 (1955) In Russian.

In the process of diffraction scattering by black (or grey) nuclei, momentum is transferred by the deuteron to the nucleus as a whole. As a result, the deuteron can split into neutron plus proton. The main part of this effect can be obtained by calculating the matrix element of $U+W$, where U is the n–p potential and W is the electric field from the nucleus, between an initial state describing incident deuteron plus diffracted wave and a final state of outgoing neutrons and protons. G. E. Brown

539.172.13

9080. Angular distribution of the neutrons from the reaction $Be^9(d,n)B^{10}$. J. GÉNIN. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 26, 2514–17 (*June* 27, 1955) In French.

The angular distribution of the neutrons associated with the lowest five levels in B^{10} were studied by a photographic plate method. The incident deuteron energy was 695 keV, and at this energy only one of the five groups showed evidence for the stripping process.

J. M. CASSELS

539.172.13

9081. An accurate determination of the energy of the $D(d,n)^3He$ reaction. S. SUBOTIĆ AND B. MAGLIĆ. Letter in *Phil. Mag.*, **46,** 805–7 (*July*, 1955).

The Q-value of the $D(d,n)He^3$ reaction has been determined as $3{\cdot}276 \pm 0{\cdot}024$ MeV. The neutrons produced in a thick heavy ice target by $85{\cdot}2 \pm 20$ keV deuterons were detected by photographic plates. Only knock-on protons scattered within an angle less than 5° to the neutron direction were accepted. Range, angular and thick target straggling were calculated and the neutron energy extrapolated. The result compares favourably with the most accurate result yet quoted ($3{\cdot}265 \pm 0{\cdot}018$ MeV obtained by measurements on the He^3-recoils using a doubly focusing magnetic spectrometer). D. J. PROWSE

539.172.13

9082. An analysis of the neutrons from $^7Li(dn)^8Be$ at 880 keV. W. M. GIBSON AND D. J. PROWSE. Letter in *Phil. Mag.*, **46,** 807–9 (*July*, 1955).

The energy levels of Be^8 up to 6 MeV have been determined by a careful analysis of the neutrons from the reaction $Li^7(d,n)Be^8$ at a deuteron energy of 880 keV. The target was 100 keV thick and the neutrons were observed at an angle of 120°. Only "knock-on" protons making an angle of less than 12° with the incident neutron direction were measured. Tracks of range $<200\,\mu$ were ignored. The neutron groups visible are those due to the ground state and excited states at 2·1, 2·9, 4·05 and 5·25 MeV of Be^8. The intensities of the 2·1, 4·05 and 5·25 MeV groups were appreciable and well above background level.

D. J. PROWSE

539.172.13

9083. An investigation of the neutron groups from the disintegration of phosphorus by 8 MeV deuterons. F. A. EL BEDEWI AND M. A. EL WAHAB. *Proc. Phys. Soc. A*, **68,** *Pt* 8, 754–9 (*Aug.*, 1955).

The energy spectrum and angular distributions of some neutron groups emitted from the bombardment of a thin phosphorus target by 8 MeV deuterons have been investigated. The Q-value of this reaction is found to be $6{\cdot}63 \pm 0{\cdot}08$ MeV. New excited states in S^{32} at 6·29, 7·28 and 8·23 MeV, with errors of $\pm 0{\cdot}10$ MeV have been observed. Angular distributions of neutron groups corresponding to the transition to the ground state and two excited states at 2·25 MeV and 3·81 MeV in S^{32} are compared with theoretical curves calculated on the basis of Butler and Born approximation stripping theories. The angular momentum of the captured proton to these states is found to be 0, 2 and 0 respectively. In an appendix, R. Huby and H. C. Newns discuss the interpretation of these results on the shell model. A.

539.172.13 : 539.152.1

9084. Deuteron reactions and the j–j coupling shell model. J. B. FRENCH AND B. J. RAZ. Letter in *Phys. Rev.*, **98,** *No.* 5, 1523–4 (*June* 1, 1955).

Angular distributions and relative cross-sections in stripping or pick-up reactions for low-lying levels of the same parity with $J=j$ and $J=j-1$ should give rather directly the departure from pure j–j coupling. A survey of cases of interest is made for the $3d_{5/2}$, $4f_{7/2}$ and $5g_{9/2}$ subshells. W. J. SWIATECKI

539.172.13 : 778.34

9085. Abacus for simplifying the calculations of neutron energy in (d,n) reactions. II. J. CATALÁ, J. AGUILAR AND F. SENENT. *An. Real Soc. Españ. Fís. Quím.*, **51**(A), *No.* 5–6, 141–8 (*May–June*, 1955) In Spanish.

The construction and method of use is described. It is more accurate than that described in the previous part [Abstr. 6892 (1954)] for particles of low energy.

J. J. PHIPPS

539.172.3

9086. The excitation function of the reaction $Li(\gamma,n)He$. F. HEINRICH AND R. RUBIN. *Helv. phys. Acta*, **28,** *No.* 2–3, 185–92 (1955) In German.

The integral excitation curve was measured for this reaction using the continuous radiation from a 31 MeV betatron. The differentiated curve had maxima at ~15, 21 and 29 MeV, of which the first two are attributed to electric quadrupole (or magnetic dipole) and the last to electric dipole absorption. Resonances at the first two energies had previously been found in the reaction $Li(\gamma,p)$ [Rubin and Walter (1954)].

J. HUGHES

539.172.3

9087. Yield and angular distribution of photoneutrons of high energy. P. S. BARANOV AND V. I. GOL'DANSKIĬ. Letter in *Zh. éksper. teor. Fiz.*, **28,** *No.* 6, 746–8 (1955) In Russian.

With a high-threshold scintillation detector [Abstr. 9159 (1955)] neutrons from bremsstrahlung photons of energies to 250 MeV on Be, C, Al and Pb are registered. Dependence of the yield on maximum bremsstrahlung energy is measured. G. E. BROWN

539.172.3

9088. On activation curves for the (γ,n) reaction near threshold. R. BASILE AND C. SCHUHL. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 25, 2399–401 (*June* 20, 1955) In French.

Measurements on the $O^{16}(\gamma,n)$ and $P^{31}(\gamma,n)$ reactions are reported. The $P^{31}(\gamma,n)$ threshold is $12{\cdot}33 \pm 0{\cdot}05$ MeV, and the activation curve exhibits sudden changes of slope at $12{\cdot}58 \pm 0{\cdot}07$, $12{\cdot}75 \pm 0{\cdot}08$, $12{\cdot}90 \pm 0{\cdot}08$, $13{\cdot}18 \pm 0{\cdot}10$ and $13{\cdot}38 \pm 0{\cdot}10$ MeV.

J. J. WILKINS

539.172.3

9089. On the activation curve of the reaction $P^{31}(\gamma,n)P^{30}$ near threshold. C. SCHUHL AND R. BASILE. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 26, 2512–14 (*June* 27, 1955) In French.

Discussion of results already reported (preceding abstract). The mass of P^{30} and the upper limit ($3{\cdot}23 \pm 0{\cdot}12$ MeV) of its β^+-spectrum are deduced.

J. J. WILKINS

539.172.3

9090. Study of the recoil of Cu^{62} obtained by the reaction $Cu^{63}(\gamma,n)Cu^{62}$. Application to the preparation of carrier-free Cu^{62}. P. SÜE AND J. PAULY. *C.R. Acad. Sci.* [*Paris*] **241,** *No.* 2, 197–9 (*July* 11, 1955) In French.

See Abstr. 8248 (1955). A finely divided sample of copper or copper sulphate was mixed with a suitable powder (e.g. $CaCO_3$), which served to collect the recoil Cu^{62} nuclei. Using copper sulphate, a 39% yield of Cu^{62} was obtained, indicating a recoil range $0{\cdot}26\,\mu$. Using metallic copper, the corresponding values were $3{\cdot}5\%$ and $0{\cdot}06\,\mu$. J. J. WILKINS

539.172.3

9091. Cross sections for the reaction $^{12}C(\gamma,3\alpha)$ in the energy range 12–18 MeV. J. H. CARVER, H. J. HAY AND E. W. TITTERTON. *Phil. Mag.*, **46,** 841–9 (*Aug.*, 1955).

By combining results obtained from a methane counter with those from nuclear emulsions the cross-sections for the $C^{12}(\gamma,3\alpha)$ reaction at 17·6, 14·8 and 12·3 MeV are found to be $(1{\cdot}70 \pm 0{\cdot}24)$, $(0{\cdot}33 \pm 0{\cdot}07)$ and $(1{\cdot}15 \pm 0{\cdot}6)\times10^{-28}\,cm^2$ respectively. Analysis of the data suggests a strong resonance in the excitation function near 12·3 MeV and possible resonances near 15 and 16 MeV. A.

539.172.3

9092. Elastic photoproduction of π^0 mesons in helium and (γ,n) reaction on helium at high energies. G. DESAUSSURE AND L. S. OSBORNE. *Phys. Rev.*, **99,** *No.* 3, 843–8 (*Aug.* 1, 1955).

The "elastic" photoproduction of π^0-mesons in helium has been measured as a function of centre-of-mass angle for γ-ray energies from 170 MeV to 340 MeV. The total cross-section shows a maximum around 270 MeV excitation energy and the angular distribution at 300 MeV peaks around 65° in the centre-of-mass system. An attempt has been made to interpret the results in terms of the differential cross-section for photoproduction of π^0-mesons in hydrogen, and to obtain (from the amount of interference of the waves emitted by the four nucleons) a value for the "mean radius" of the α-particle and the relative phase of π^0-emission from proton and neutron. The photodisintegration reaction $\gamma + He^4 \rightarrow He^3 + n$ has also been investigated. The angular distribution of the He^3 recoil nuclei is found to be proportional to $\sin^2\theta$ for excitation energies between 40 MeV and 120 MeV. A.

539.172.3

9093. Fine structure in the photoproton spectrum of oxygen. S. A. E. JOHANSSON AND B. FORKMAN. Letter in *Phys. Rev.*, **99,** *No.* 3, 1031–2 (*Aug.* 1, 1955).

The photoproton spectrum has been measured with a nuclear plate camera for 21 MeV incident bremsstrahlung. The results indicate sharp resonances in the cross-section curve. J. J. WILKINS

539.172.3

9094. Shell effect on photonuclear reactions. J. GOLDEMBERG AND J. LEITE LOPES. Letter in *Phys. Rev.*, **99,** *No.* 3, 1053–5 (*Aug.* 1, 1955).

The energy difference between the (γ, n) threshold and the first point at which the (γ, n) cross-section reaches half its maximum value is plotted against mass number A. The resultant curve peaks in general at magic number nuclei, but exhibits anomalies for low A and for the nuclei Nb and Mo. J. J. WILKINS

539.172.3 : 539.152.1

9095. Collective aspects of nuclear photo-effect. U. L. BUSINARO AND S. GALLONE. Letter in *Nuovo Cimento* (*Ser.* 10) **1,** *No.* 6, 1285–8 (*June*, 1955).

The frequency and resonance width for a dipole oscillation of one spherical distribution of nucleons with respect to another is estimated from the perturbation energy of single particle levels in corresponding spherical potential wells, assuming proportionality between potential depth and particle density. Results of the observed order of magnitude are found. W. J. SWIATECKI

539.172.4

9096. Maximum number of photo-neutrons and a new method of defining the integral cross-section of (γ, n) reactions for photons of high energies. V. I. GOL'DANSKIĬ AND V. A. SHKODA-UL'YANOV. Letter in *Zh. éksper. teor. Fiz.*, **28,** *No.* 5, 623–6 (1955) In Russian.

The theory of integral neutron formation in passage of photons through thick slabs is worked out with formulae from cascade theory. The giant dipole photo-nuclear resonance is important in this. Experiments in which bremsstrahlung of maximum energy 250 MeV is directed into blocks of various materials are described. G. E. BROWN

539.172.4

9097. 14-MeV (n,α) cross-sections in zirconium. I. J. E. BROLLEY, JR, M. E. BUNKER, D. R. F. COCHRAN, R. L. HENKEL, J. P. MIZE AND J. W. STARNER. Letter in *Phys. Rev.*, **99,** *No.* 1, 330 (*July* 1, 1955).

The (n, α) cross-sections in Zr were determined for two neutron energies by estimating the Sr^{87m} and Sr^{91} activities in Zr targets. For 14·1 and 14·9 MeV neutrons values of $3{\cdot}1 \pm 0{\cdot}2$ and $3{\cdot}0 \pm 0{\cdot}2$ mb for Zr^{90}, and $4{\cdot}9 \pm 0{\cdot}6$ and $3{\cdot}9 \pm 0{\cdot}5$ mb for Zr^{94} were found. This result and those of the two abstracts following are discussed. M. A. GRACE

539.172.4

9098. 14-MeV(n, α) and (n, p) cross sections in zirconium. II. A. H. ARMSTRONG AND J. E. BROLLEY, JR. Letter in *Phys. Rev.*, **99,** *No.* 1, 330–1 (*July* 1, 1955).

For 14·1 MeV neutrons a total (n, α) cross-section of 10 ± 10 mb was found by counting α-particle tracks (energy >3 MeV) in nuclear plates. A value of 180 ± 70 mb for the (n, p) cross-section was obtained. See preceding abstract. M. A. GRACE

539.172.4

9099. 14-MeV (n, α) cross section in zirconium. III. F. L. RIBE AND R. W. DAVIS. Letter in *Phys. Rev.*, **99,** *No.* 1, 331–2 (*July* 1, 1955).

The angular distribution of the α-particles from this reaction was determined using a counter telescope and is predominantly in the forward hemisphere. The integrated cross-section was found to be 7 ± 2 mb. See preceding abstract. M. A. GRACE

539.172.4

9100. Systematics of neutron capture cross sections. B. G. HARVEY. Letter in *Phys. Rev.*, **99,** *No.* 1, 333–4 (*July* 1, 1955).

A graph is given showing that, for elements heavier

than lead, there exists a rough correlation between the neutron binding energy and the sum of the capture and fission cross-sections. The correlation is most marked for the even–even nuclei. A brief discussion of some marked exceptions to, and the possible explanation for, the correlation is given. J. HUGHES

539.172.4

9101. Experimental checks of the statistical theory of nuclear reactions. L. ROSEN AND L. STEWART. Letter in *Phys. Rev.*, **99**, *No.* 3, 1052–3 (*Aug.* 1, 1955).

A bismuth target was irradiated with 14 MeV neutrons, and scattered neutrons were detected in nuclear emulsions. Distributions in energy and angle of the inelastically scattered neutrons are reported and discussed. J. J. WILKINS

539.172.4

9102. Inelastic scattering of 2·5 MeV neutrons by ^{54}Fe and ^{56}Fe. L. E. BEGHIAN, D. HICKS AND B. MILMAN. *Phil. Mag.*, **46**, 963–7 (*Sept.*, 1955).

A NaI(Tl) crystal was used to study the γ-radiations emitted by natural iron, Fe^{54} and Fe^{56} scatterers. Gamma-rays of the following energies were observed: from natural iron $0{\cdot}85 \pm 0{\cdot}03$, $1{\cdot}22 \pm 0{\cdot}05$, $1{\cdot}42 \pm 0{\cdot}05$ MeV. The 1·4 MeV γ-ray was not present with the Fe^{56} scatterer. A $1{\cdot}37 \pm 0{\cdot}05$ MeV line was observed with the Fe^{54} scatterer. In addition the neutrons scattered from natural iron were studied with a stilbene crystal, and groups corresponding to levels at $0{\cdot}85 \pm 0{\cdot}03$ MeV and $1{\cdot}45 \pm 0{\cdot}05$ MeV were found. On the basis of the above the following levels can be identified: in Fe^{56} $0{\cdot}85 \pm 0{\cdot}03$ MeV, $2{\cdot}07 \pm 0{\cdot}05$ MeV, in Fe^{54} $1{\cdot}40 \pm 0{\cdot}05$ MeV. A.

539.172.4 : 539.163.1

9103. The thermal neutron capture cross section of AU^{198} and the half-life of Au^{199}. R. E. BELL, R. L. GRAHAM AND L. YAFFE. *Canad. J. Phys.*, **33**, *No.* 8, 457–65 (*Aug.*, 1955).

The thermal neutron capture cross-section of radioactive Au^{198} has been measured by the activation method as 26000 ± 1200 barn, assuming 99 barn for the thermal neutron cross-section of Au^{197}. Metallic Au^{197} was bombarded in fluxes up to 9×10^{13} thermal neutrons $cm^{-2}sec^{-1}$ to produce a mixture of Au^{198} and Au^{199} by the successive neutron capture reactions $Au^{197}(n, \gamma)Au^{198}(n, \gamma)Au^{199}$. The ratio of the Au^{199} activity to Au^{198} activity so produced yields $\sigma_c(Au^{197})$. In a preliminary experiment, the half-life of Au^{199} was measured as $3{\cdot}148 \pm 0{\cdot}010$ days. A.

539.172.4 : 778.34

9104. Escape fraction of recoil protons caused by incident neutrons in photographic plates. J. CATALÁ, F. SENENT, J. AGUILAR AND R. FONT. *An. Real. Soc. Espan. Fis. Quim.*, **51(A)**, *No.* 5–6, 127–40 (*May–June*, 1955) In Spanish.

A theoretical method is presented for calculating the escape fraction, $f(E)$, which depends upon the incident neutron energy, emulsion thickness, and the max. angle of diffusion of the protons. Graphs are given of the functions from which $f(E)$ may be derived. The true number of incident neutrons, $N_r(E)$, of a given energy, (E), is obtained from the number of proton tracks, $N_m(E)$, using the relation: $N_r(E) = K.N_m(E)/\sigma(E)f(E)$ where K depends upon the volume of the emulsion and its hygrometric state, and $\sigma(E)$ is the effective cross-section. Using this equation, the histogram for neutrons emitted in the $Li^7(d, n)Be^8$ reaction [Abstr. 758 (1954)] is corrected, the correction factor $\{\sigma(E)f(E)\}^{-1}$ being unity at 6 MeV and increasing with increasing energy. Examples are given of neutrons entering the emulsion at grazing angles of 0, 10 and 15°, considering only those recoil proton tracks within 20° of the direction of the neutrons, and the graph of their $f(E)$ is given. A bibliography is included. J. J. PHIPPS

539.172.4

9105. Saddle shapes, threshold energies and fission asymmetry on the liquid drop model. U. L. BUSINARO AND S. GALLONE. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 6, 1277–9 (*June*, 1955).

The calculations of Abstr. 5644 (1955) are extended by including α_2P_2 type deformations of the basic ellipsoid. Thresholds calculated down to "x" $= 0{\cdot}7$ are consistent with those of Frankel and Metropolis (1947). W. J. SWIATECKI

539.172.4

9106. Thermodynamic theory of fission. J. K. PERRING AND J. S. STORY. Letter in *Phys. Rev.*, **98**, *No.* 5, 1525–6 (*June* 1, 1955).

Using Fong's prescription [Abstr. 2727 (1953)] (successful in reproducing the thermal neutron fission yield from U^{235}) in the case of Pu^{239}, a yield curve in qualitative disagreement with experiment was found. W. J. SWIATECKI

539.172.4

9107. Angular dependence of the neutron-induced fission process. II. J. E. BROLLEY, JR, W. C. DICKINSON AND R. L. HENKEL. *Phys. Rev.*, **99**, *No.* 1, 159–65 (*July* 1, 1955).

For previous part, see Abstr. 6907 (1954). The angular anisotropy of neutron-induced fission has been studied with a double fission chamber. For U^{235} at 7·4 MeV and Np^{237} at 14·3 MeV, the variation of the differential fission cross-section was found to depend strongly on the fourth power of the cosine of the angle between the fission fragment and the neutron beam. For U^{235} a resonance-type dependence of the anisotropy on neutron energy has been observed. Qualitative indication that the light and heavy fission fragment groups have slightly different anisotropies has been obtained in the case of Np^{237} at 14·3 MeV. A.

539.172.4

9108. Slowing down distribution of U^{235} fission neutrons from a point source in light water. J. E. HILL, L. D. ROBERTS AND T. E. FITCH. *J. appl. Phys.*, **26**, *No.* 8, 1013–18 (*Aug.*, 1955).

The results of a measurement of the slowing down distribution in water of neutrons from a point fission source to indium resonance energy, 1·458 eV are given. The second, fourth, sixth and eighth moments of the measured distribution are calculated and have the values, $\bar{r}^2 = 184{\cdot}7\,cm^2$, $\bar{r}^4 = 1{\cdot}222\times10^5\,cm^4$, $\bar{r}^6 = 2{\cdot}27\times10^8\,cm^6$, and $\bar{r}^8 = 8{\cdot}6\times10^{11}\,cm^8$. A.

539.172.4

9109. Slowing down distribution to indium resonance of U^{235} fission neutrons from a point fission source in two aluminium light water mixtures. L. D. ROBERTS, J. E. HILL AND T. E. FITCH. *J. appl. Phys.*, **26**, *No.* 8, 1018–21 (*Aug.*, 1955).

The mean square slowing down length, $\bar{r}^2$, has been

measured for two aluminium light water mixtures, the aluminium-to-water volume ratios being 1 : 1 and 1 : 2 by volume. The values of $\bar{r}^2$ obtained are 460·7 cm^2 and 297·4 cm^2, respectively. A.

539.172.4

9110. The fission yields of isotopes of xenon and krypton in the neutron fission of U^{235} and U^{238}. R. K. Wanless and H. G. Thode. *Canad. J. Phys.*, **33**, *No.* 9, 541–54 (*Sept.*, 1955).

Several uranium samples have been irradiated under various conditions in the Chalk River N.R.X. reactor and in the Los Alamos fast reactor. The fission gases, xenon and krypton, have been extracted from the irradiated material and the relative isotopic abundances determined mass spectrometrically. Fine structure in the mass–fission yield curve has been found in both the xenon and krypton mass ranges for $U^{235} + n$ and $U^{238} + n$ fission. It is observed that this fine structure shifts to lower masses, as predicted, for neutron fission of U^{238}. The proportions of U^{235} and U^{238} fission that have occurred in the irradiated samples have been estimated from the percentage change in fine structure. A.

539.172.4

9111. Determination of functions for the energy distribution of neutrons by the method of Markov. V. V. Chavchanidze and O. D. Cheĭshvili. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 369–70 (1955) In Russian.

The slowing down of neutrons by elastic collisions with moderator nuclei is treated by the Markov method for stochastic processes. An expression is derived for the probability that U will lie in the interval between U and $U + dU$, where $U = \log (E_0/E_n)$, E_0 is the initial energy of the neutron and E_n after n collisions with moderator of atomic mass A. According to the authors the treatment is applicable to the case of a small number of elastic collisions in thin layers of the moderator. S. DEDIJER

539.172.4

9112. The distribution of γ-rays and neutrons in the control face shield of B.E.P.O. J. R. Harrison, A. M. Mills and D. Bendell. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. RP/R*1604, 8 *pp.* (1955).

Measurements of neutron and γ-ray fluxes in the control face shield of B.E.P.O. have been made. The measurements extend over the entire thickness of the shield (6 ft 6 in. Barytes concrete), and cover a range of 10^7 in γ-ray and thermal neutron intensities. It is shown that 43 in. of concrete would have been sufficient for maximum permissible levels for all radiations to have been obtained. A.

539.172.4

9113. Diffusion in a cylindrical reactor with all-round reflector. A. Hassitt. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. T/M*123, 8 *pp.* (1955).

One-group diffusion theory, in a cylindrical reactor with all-round reflector, is considered. The advantages of using relaxation methods are described. A finite difference equation, correct to order h^4, is found, which describes the behaviour of the neutron distribution at an interface. A method of subdividing meshes, in a cylindrical geometry, is given. Higher difference corrections for a cylindrical geometry are discussed, and it is shown how they improve the accuracy of the answer. Results are given for a small homogeneous reactor, with heavy-water reflector. The accuracy of the relaxation solution is better than ½%. The usual approximate methods, for setting upper and lower limits to the diffusion length, are discussed, and it is shown that they may be in error by 5%. A.

539.172.4 : 523.877

9114. Radiation flux field outside of stars and spherical reactors. M. A. Melvin. *Phys. Rev.*, **99**, *No.* 2, 371–5 (*July* 15, 1955).

The energy density U, flux density F and pressure P in the field of a hot spherical system, are here investigated along with their neutron-flux analogues. General expressions for U, F and P are obtained and evaluated in particular (1) outside of spherical bodies radiating according to Lambert's law of isotropic radiance, I = constant, and (2) outside of stars or spherical reactors. Radiative (or transport) balance within a star (or reactor) leads to an angularly dependent radiance, $I(\cos\theta)$, from the outer surface. Assuming I to be given up to quadratic terms in $\cos\theta$, analytic expressions for U and P are obtained. It is further shown how one may use known exact numerical values for the radiance and its derivatives, at $\cos\theta = 0$ and 1, to give still better analytic representations. For many purposes where one wishes to carry out calculations involving U or P, it is convenient to have simple analytic approximations for these quantities; such approximations are here given in the form of simple Lambert-law expressions multiplied by suitable factors. A.

ATOM AND MOLECULAR BEAMS . MESONS NEUTRONS 539.18

539.18

9115. Theory of the Λ^0-particle. P. S. Isaev and M. A. Markov. *Zh. éksper. teor. Fiz.*, **29**, *No.* 1(7), 111–14 (1955) In Russian.

A class of equations is considered of which the lowest eigenstate describes the proton, the first excited state, the Λ^0-particle. G. E. BROWN

539.18

9116. Remarks on heavy mesons. M. M. Lévy and R. E. Marshak. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 253–6 (1954).

A quantum number "ω-parity" is assigned to pions and nucleons: even ω-parity to pions and nucleons ($\pi_0 N_0$) and odd ω-parity to their first excited states ($\pi_1 N_1$). τ and θ mesons are identified with $^1S_0$ and $^3P_0$ states of the bound systems ($N_0\bar{N}_1$) and/or ($\bar{N}_0 N_1$) and their production and absorption mechanisms predicted. P. ROTHWELL

539.18 : 537.591.8

On a super-σ star produced by the capture of a K_σ meson. *See Abstr.* 8891

539.18

9117. Negative *K*-mesons. M. Baldo, M. Ceccarelli, M. Grilli and G. T. Zorn. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 257–9 (1954).

Details of three K^- events and the capture of a negative hyperon observed in stripped emulsion exposed at high altitude are given. The particles were identified through systematic mass measurements on the tracks of τ-mesons. P. ROTHWELL

539.18

9118. Two examples of nuclear interaction of *K*-particles at rest. M. Di Corato, B. Locatelli, G. Mignone and G. Tomasini. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 270–2 (1954).

Details of two events, type σK, found in stripped emulsion exposed at balloon altitude, are given. One of these events probably contains a Y_L particle, which decays according to the scheme $Y_L \rightarrow \pi + n + Q$, where $Q = 95 \pm 21$ MeV. The mass of the Y_L particle, on this assumption, is about 2 300 m_e and its kinetic energy of emission 60 MeV. P. ROTHWELL

539.18

9119. Two K^--interactions. I. Macpherson, J. V. Major, Om Parkash, G. D. Rochester and A. M. Short. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 275–9 (1954).

Details of two *K*-particles, observed in G5 emulsion exposed at 30 000 ft, which were absorbed by nuclei of the emulsion to form *K*-stars, are given. The masses of the primary particles were determined by three methods, scattering range, gap-length range, and by a photometric method. The masses of the secondaries were found by the scattering-grain density method. P. ROTHWELL

539.18

9120. Discussion of stars produced by negative *K*-mesons. N. Dallaporta and G. Lanza. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 260–9 (1954).

An attempt is made to explain the experimental features of stars produced by K^--mesons, without introducing any new mechanism of K^- capture. Three cases are examined: (1) κ-particles are weakly interacting with nuclei; (2) τ-particles are weakly interacting with nuclei; (3) κ- or τ-particles are strongly interacting with nuclei and the results of the analysis are compared with the limited experimental data available. P. ROTHWELL

539.18 : 537.591.8

An analysis of a *K*-meson star. *See Abstr.* 8890

539.18

9121. An analysis of three τ-mesons. G. Baroni. Letter in *Nuovo Cimento* (*Ser.* 10) **2**, *No.* 1, 169–71 (*July*, 1955).

539.18

9122. Bevatron *K*-mesons. R. W. Birge, R. P. Haddock, L. T. Kerth, J. R. Peterson, J. Sandweiss, D. H. Stork and M. N. Whitehead. Letter in *Phys. Rev.*, **99**, *No.* 1, 329–30 (*July* 1, 1955).

A strong-focusing spectrometer was used to focus particles of any desired momentum from the bevatron. An emulsion stack was placed at the focus and particles of different mass could then be separated by their ranges. A stack exposed to 114 MeV *K*-mesons was scanned for tracks whose ionization was visibly greater than minimum and these were followed until they stopped and the endings examined for decays. 300 decays have so far been found of which 20 have been identified as decays of τ-mesons and 3 as τ'-mesons. The mean life of any of these *K*-mesons is unlikely to be less than 3×10^{-9} sec. The momentum resolution allows a mass determination to $\pm 40\, m_e$ on each *K*-meson. The measured τ-mass was $974 \pm 6\, m_e$ and indicates a slight systematic error. D. J. PROWSE

539.18

9123. Measurements on *K*-particles from the bevatron. W. W. Chupp, G. Goldhaber, S. Goldhaber, S. J. Goldsack, J. E. Lannutti, F. M. Smith and F. H. Webb. Letter in *Phys. Rev.*, **99**, *No.* 1, 335–6 (*July* 1, 1955).

Stacks of nuclear emulsions were exposed to the direct proton beam of the Berkeley bevatron and to the secondaries emitted at 90° to the target. The time of flight for the *K*-particles observed was 10^{-9} sec. So far 35 *K*-particles and 5 τ-mesons have been found (mostly in the exposure to secondaries). The masses were determined using the grain count *v.* range method for those in the region 1–3 cm residual range and using "opacity" measurements for those of shorter range. The weighted average gives $936 \pm 11\, m_e$. This would indicate the presence of a particle lighter than the τ-meson, although this cannot be considered definite. One example has been identified as a K_β. Only one *K*-particle with no secondary was found and this is therefore presumably negative. No *K*-particles giving rise to a star have yet been found. D. J. PROWSE

539.18

9124. Further observations of negative *K* mesons. J. Hornbostel and E. O. Salant. Letter in *Phys. Rev.*, **99**, *No.* 1, 338–9 (*July* 1, 1955).

In a continuation of earlier work [Abstr. 6491 (1955)] 22 negative *K*-mesons have been found with stars at the end of their range. The known momentum of the *K*-mesons was 313 ± 3 MeV/c and their range was found to be $45{\cdot}8 \pm 0{\cdot}8$ mm giving a mean mass of $931 \pm 24\, m_e$. Five K^--mesons have been observed to give stars in flight, resulting in a collision mean-free-path of 20 cm. Some ρK-mesons have also been observed. D. J. PROWSE

539.18

9125. A possible example of the decay in flight of a θ^0. M. Di Corato, C. C. Dilworth and L. Scarsi. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 285–7 (1954).

A 2-branch star was found during scanning of stripped emulsion exposed at balloon altitude. One branch was identified as a π^--meson; the other had grain density close to minimum. Scattering measurements were made on the minimum track; if it is assumed to be a π-meson, and the event represents the decay in flight of a neutral particle $X^0 \rightarrow \pi^+ + \pi^- + Q$, the *Q*-value obtained is $220 \begin{smallmatrix} +35 \\ -30 \end{smallmatrix}$ MeV. There are other interpretations of the event which cannot be excluded, however. P. ROTHWELL

539.18 : 539.165.2

9126. μ-meson decay and β-decay processes. B. Stech and J. H. D. Jensen. *Z. Phys.*, **141**, *No.* 4, 403–10 (1955) In German.

A symmetry argument, applied to the β-decay case in a previous paper [Abstr. 6435 (1955)], gives rise to two possible decay spectra for the muon decay. Experimental evidence favouring one or the other would show whether the μ^+ or the μ^- is an antiparticle, assuming the electron to be a "particle." G. FIELD

539.18

9127. Possible β-decay of hyperons and *K*-mesons. M. Markov and V. Stakhanov Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 6, 740 (1955) In Russian.

The Λ^0-particle is viewed as an excited state of the nucleon and might be thought to decay as $\Lambda^0 \rightarrow P + e^- + \nu$. Because of the large energy, the lifetime for β-decay would be 10^{-9} sec and the decay seems ruled out by experiment. G. E. BROWN

539.18

9128. Nature of the neutral secondary particle produced in the decay of the $K_{\pi 2}$-meson. H. DeStaebler, Jr and B. V. Sreekantan. Letter in *Phys. Rev.*, **98**, *No.* 5, 1520–1 (*June* 1, 1955).

A summary of data on five multiplate cloud chamber events, which can be interpreted as $K_{\pi 2} \rightarrow \pi + \pi^0$, with a primary mass of $952 \pm 11\,m_e$ and a mean range of the charged secondary of $43{\cdot}0 \pm 1{\cdot}6\,g.cm^{-2}$ brass. W. J. Swiatecki

539.18

9129. Preliminary data on the measurement of the $\mu^+ - \beta^+$ decay spectrum. K. M. Crowe, R. H. Helm and G. W. Tautfest. *Phys. Rev.*, **99**, *No.* 3, 872–4 (*Aug.* 1, 1955).

The results of a preliminary nature on the $\mu - \beta$ decay spectrum are given. The data are consistent with a theory as proposed by Michel with a parameter $\rho = 0{\cdot}50 \pm 0{\cdot}10$. The background and systematic errors are discussed. A.

539.18

9130. Radiative τ-meson decay. R. H. Dalitz. *Phys. Rev.*, **99**, *No.* 3, 915–20 (*Aug.* 1, 1955).

The characteristics of the decay process $\tau^\pm \rightarrow \pi^\pm + \pi^+ + \pi^- + \gamma$ are considered. For a pseudoscalar τ-meson, the probability $R(k)$, relative to the 3π-decay, for emission of a photon of energy k MeV or greater is found to be $1{\cdot}06 \times 10^{-3}$ for $k = 10$ and $1{\cdot}1 \times 10^{-4}$ for $k = 30$. Quite similar values are obtained for other spin values compatible with the τ-meson decay data. Branching ratios for other decay processes are briefly discussed and it is suggested that the absence of the decay mode $\pi^\pm + \gamma$ or $\pi^\pm + e^+ + e^-$ may provide some evidence against a non-zero τ-meson spin. Competing decay processes involving a neutrino are not considered. A.

539.18

9131. π–μ decay with an associated electron pair. W. F. Fry, J. Schneps, G. A. Snow and M. S. Swami. Letter in *Phys. Rev.*, **99**, *No.* 3, 1055–6 (*Aug.* 1, 1955).

A π–μ decay has been observed in which two minimum ionizing tracks emerge from the decay point. These have been proved to be electron tracks. The energy of each was 0·6–0·3 MeV from scattering measurements; the angle of opening was 25°. The kinematics are in agreement with the assumption that the electron pair was directly produced during the decay—a process which would have been thought very rare ($\sim 10^{-6}$). D. J. Prowse

539.18 : 535.33 : 537.531

X-rays from π-mesonic atoms. *See Abstr.* 8805–6

539.18

9132. Masses of the new particles and the range-energy relation. D. O. Caldwell. Letter in *Nuovo Cimento* (*Ser.* 10) **2**, *No.* 1, 183–5 (*July*, 1955).

It is pointed out that the main uncertainty in the range-energy relation arises from a lack of precise knowledge of the value of the mean excitation potential. The available data on the mean excitation potential for copper is critically discussed. H. Elliot

539.18

9133. Observations on *S* particles. J. Ballam, A. L. Hodson and G. T. Reynolds. Letter in *Phys. Rev.*, **99**, *No.* 3, 1038 (*Aug.* 1, 1955).

The Princeton dual cloud chamber has been used to determine the mass of the $K_{\mu 2}$ particle. These measurements confirm the evidence of the Paris group that the $K_{\mu 2}$ has a mass lower than the τ-meson. A. J. Egginton

539.18

9134. Masses of *S* particles. G. T. Reynolds and W. A. Aron. Letter in *Phys. Rev.*, **99**, *No.* 3, 1038–9 (*Aug.* 1, 1955).

The masses of *K*-mesons when measured have differed systematically in value depending on the method of measurement used. It is pointed out that an error in the value of the mean excitation potential I used would lead to a shift in the range-energy curves from which the masses are deduced. A value $I = 13{\cdot}0\,Z$ has been taken and applied to the various published results. It is successful in reducing the gap between these results to within statistical error. A. J. Egginton

539.18

9135. *K*-meson mass from a *K*-hydrogen scattering event. W. W. Chupp, G. Goldhaber, S. Goldhaber, W. R. Johnson and J. E. Lannutti. Letter in *Phys. Rev.*, **99**, *No.* 3, 1042–3 (*Aug.* 1, 1955).

A *K*-proton scattering event has been observed in a nuclear emulsion stack exposed to a focused beam of K^+-mesons. The scattered *K*-meson and the proton are both arrested in the stack, the *K*-meson decaying at rest into a light meson. Measurements on this secondary indicate that the likelihood of the parent meson being a τ' is small although no other distinction is possible. The mass has been determined in two ways: from the scattered *K*-meson range and the conservation of transverse momentum—this method gives $972 \pm 12\,m_e$, and from the conservation of energy and momentum in the scattering event, giving $984 \pm 79\,m_e$. The weighted mean is given as $973 \pm 12\,m_e$. D. J. Prowse

539.18 : 537.534

Determination of masses of charged particles by scattering on plates and residual range inside a Wilson chamber. *See Abstr.* 8836

539.18

9136. Multiple scattering corrections in π± deuteron scattering. S. D. Drell and L. Verlet. *Phys. Rev.*, **99**, *No.* 3, 849–56 (*Aug.* 1, 1955).

Multiple-scattering corrections to the impulse approximation are calculated for the scattering of $\pi^\pm$-mesons by deuterons. These corrections are model-dependent since the scattered wave propagates off the energy shell between the first and last scatterings whereas experimental scattering phase shifts are available only for elastic scattering. Various assumptions are made concerning the off-the-energy-shell behaviour of the scattering amplitudes and the double-scattering approximation is analysed for meson energies of 45 and 169 MeV. The results are tabulated and

are found to be sensitive to the different scattering models. The cross-sections at 169 MeV were calculated with both the Fermi and Bethe solutions for the meson–nucleon scattering phase shifts and are in close agreement. It thus does not seem to be feasible to use $\pi^{\pm}$–D scattering as a means of distinguishing between these two solutions. A.

539.18

9137. Second maximum in the negative pion scattering cross section. F. J. Dyson. Letter in *Phys. Rev.*, **99,** *No.* 3, 1037 (*Aug.* 1, 1955)

The maximum at 900 MeV in the π^-–p scattering might arise from a resonant elastic scattering of the incident meson by a meson in the charge cloud around the proton. Predictions from this hypothesis are noted. G. E. BROWN

539.18

9138. Capture of negative K mesons. S. C. Freden and H. K. Ticho. Letter in *Phys. Rev.*, **99,** *No.* 3, 1057–8 (*Aug.* 1, 1955).

Nuclear emulsions exposed to the K^--beam of the Berkeley bevatron have been scanned near the edges where the beam entered for tracks whose ionization was 2·3 times minimum. These tracks were then traced to their endings. Four endings of K^--mesons have so far been found. The capture stars do not differ significantly from those events found in cosmic radiation but they do not have the features reported for 13 stars by Hornbostel and Salent [Abstr. 6491 (1955)] in that no identified L-mesons or hyperons have been created. D. J. PROWSE

539.18

9139. Star produced by capture of a K^--meson. M. Morand and Tsai-Chü. *Nuovo Cimento Suppl.*, **12,** *No.* 2, 280 (1954) In French.

A heavy meson, whose mass from comparison with proton tracks is $1\,745 \pm 100\,m_e$, is captured and gives rise to a star with three prongs: an electron of energy ~2 MeV, a π^+-meson of energy ~27 MeV, and a minimum ionizing track. P. ROTHWELL

539.18

9140. A speculation on the capture mechanism for K-mesons. B. Touschek. *Nuovo Cimento Suppl.*, **12,** *No.* 2, 281–4 (1954).

On the assumption that the seven K^--meson capture events so far observed are due to the same type of K-meson, a mechanism for K^--meson capture of the type $K + N \rightarrow Y + \pi$ (in which Y is a hyperon) is proposed. P. ROTHWELL

539.18

9141. Total interaction cross-sections of negative π mesons with hydrogen in the energy range from 140 to 400 MeV. A. E. Ignatenko, A. I. Mukhin, E. B. Ozerov and B. M. Pontekorvo [Pontecorvo]. *Dokl. Akad. Nauk SSSR*, **103,** *No.* 1, 45–7 (1955) In Russian.

The cross-sections were determined by measuring the attenuation of the meson beam transmitted by a scatterer. A difference method (CH_2–C) was used. The recording system consisted of three scintillation counters in front of the scatterer and one behind it. The meson current density used was from 2 to 200 $cm^{-2}.sec^{-1}$. The energy of the mesons in each experiment was determined from the absorption curves in copper, which also gave the admixture of μ^--mesons. The cross-sections obtained were corrected for μ^--meson admixture, chance coincidences, miscounting, and scattered mesons and recoil protons incident inside the recording angle of the last counter. The results are given for ten values of the energy. They show that the cross-section has a maximum [previously reported: see Abstr. 5989 (1954)] near 200 MeV. It decreases as far as 300 MeV and then remains constant at 26 millibarns. The maximum value of the cross-section is its maximum possible value for the interaction of π^--mesons with hydrogen in the $P_{3/2}$ state with isotopic spin 3/2. J. B. SYKES

539.18

9142. Yields of the processes of fission and star formation accompanying the capture of π^--mesons by the nuclei U, Bi and W. N. A. Perfilov, O. V. Lozhkin and V. P. Shamov. Letter in *Zh. éksper. teor. Fiz.*, **28,** *No.* 6, 655–63 (1955) In Russian.

Photographic plates were employed, with U, Bi, W in the form of finely powdered oxides inserted in a layer not exceeding the depth of focus of the microscope so that only horizontal scanning was necessary. The numbers of stars observed in the three cases were 210, 250 and 600 respectively; the numbers of fissions, 10, 2 and 1. The numbers of tracks per star were also noted. After applying corrections for star formation in the emulsion, probabilities of fission upon capture of π^--mesons for U, Bi and W were found to be ~0·3, ~0·02 and ~0·007 respectively. Most of the stars contained no or one track. G. E. BROWN

539.18

9143. The ionization loss of relativistic μ-mesons in neon. D. A. Eyeions, B. G. Owen, B. T. Price and J. G. Wilson. **Appendix** J. M. Hammersley and K. W. Morton. *Proc. Phys. Soc. A*, **68,** *Pt* 9, 793–800 (*Sept.*, 1955).

Proportional counters filled with neon have been used in conjunction with the Manchester magnetic spectrograph to investigate the relationship between the momentum and the most probable ionization loss for μ-mesons at momenta greater than about 10^9 eV/c. The logarithmic increase of ionization loss with momentum is found to be in good agreement with that indicated by treatments which ignore interactions among the target molecules, and the onset of polarization effects is compared with that previously reported in oxygen. A.

539.18

9144. The production of heavy mesons and hyperons in nuclear disintegrations. C. Dahanayake, P. E. Francois, Y. Fujimoto, P. Iredale, C. J. Waddington and M. Yasin. *Nuovo Cimento Suppl.*, **12,** *No.* 2, 250–2 (1954).

Preliminary report of a systematic investigation of all particles with $\sim 0{\cdot}2 < \beta < 0{\cdot}55$, emitted from high-energy nuclear disintegrations. Grain density measurements are carried out on tracks, from stars with two or more secondary shower particles, which are more than twice minimum ionizing. From there, and residual range measurements, a mass spectrum of these particles is obtained. Particles of mass $1\,000\,m_e$ are well resolved from protons and may be

identified independently from secondary effects at the end of their range; but identification of hyperons is dependent on observation of secondary effects.

P. ROTHWELL

539.18

9145. Fermi's statistical theory of multiple pion production. K. K. SINGH. *Indian J. Phys.*, **29**, *No.* 4, 199–204 (*April*, 1955).

The probability for emission of N pions in a nucleon–nucleon collision is calculated on Fermi's model by applying relativistic classical thermodynamics to the "pion gas." Relative probabilities for various numbers of pions produced in a nucleon–nucleus collision are computed. A.

539.18

9146. Formation of π^0-mesons at hydrogen and deuterium by neutrons of energy 400 MeV. B. M. PONTEKORVO [PONTECORVO] AND G. I. SELIVANOV. *Dokl. Akad. Nauk SSSR*, **102**, *No.* 3, 495–7 (1955) In Russian.

This paper is based on work done in 1951–52 at the Institute of Nuclear Problems. Neutrons were obtained by the exchange interaction of protons, accelerated in the synchrocyclotron, with beryllium nuclei. The decay of π^0-mesons, formed when these neutrons irradiated paraffin and graphite targets, gave rise to γ-rays which were recorded by the apparatus described in a previous paper [Abstr. 7393 (1955)]. The total cross-section for π^0-meson formation at hydrogen was found to be $0{\cdot}4 \pm 0{\cdot}2$ millibarn. This is half the cross-section found by Passman *et al.* [Abstr. 7293 (1951)] for π^+-meson formation in proton–proton collisions. The cross-section for π^0-meson production by neutrons at deuterium was measured by irradiating light and heavy water targets, and was found to be very close to the value for hydrogen. The cross-section for π^0-meson production in neutron–neutron collisions is therefore very small. The hypothesis of charge symmetry then leads to the following scheme of π-meson formation processes when the energy of the interacting nucleons is close to the threshold:

Permitted processes	Forbidden processes
$p + p \rightarrow \pi^+$	$p + p \rightarrow \pi^0$
$n + n \rightarrow \pi^-$	$n + n \rightarrow \pi^0$
$n + p \rightarrow \pi^0$	$n + p \rightarrow \begin{cases} \pi^+ \\ \pi^- \end{cases}$

Other arguments in favour of this scheme are mentioned. The scheme indicates that mesons are most likely to be produced when the isotopic spin of the initial state of the two nucleons is unity, and of the final state zero; the converse transition is forbidden. The meson–nucleon interaction is thus strongest when the isotopic spin is 3/2 and the angular momentum $j = 3/2$, as has been found by other workers also.

J. B. SYKES

539.18

9147. Formation of π^0-mesons by 670 MeV protons on the nuclei of various elements. A. A. TYAPKIN, M. S. KOZODAEV AND YU. D. PROKOSHKIN. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 4, 689–92 (1955) In Russian.

The cross-sections of the formation of π^0-mesons by 670 MeV protons were measured in the accelerator of the Soviet Institute of Nuclear Problems for the elementary p–p collision and for collisions of protons with the nuclei of D, Li, Be, B, C, Al, Cu, Cd, Sn and Pb. The sections were determined from γ-quantum fluxes generated during the decay of the π^0-mesons, the fluxes being measured at angles 0 and 180° with regard to the direction of the protons. For the p–p collisions, the cross-section was measured differentially by irradiating polyethylene and graphite targets. The proton flux was determined from the positron activity of the irradiated targets. It was found that the effect of the 670 MeV protons differs widely from that of the 480 MeV protons (cf. Kozodaev, Tyapkin, Markov and Bayukov, Otchet Instituta Yadernykh Problem Akademii Nauk SSSR, 1952) in that an unexpected abrupt softening of the γ-quantum spectra (hence also of the π^0-meson spectra) is observed in p–C collisions under both angles. The γ-quantum yields for the angle 0° and for different elements deviate strongly from the $KA^{2/3}$ relationship, while those for 180° roughly agree with this relationship. The forward–backward γ-quantum flux ratios for various elements measured by means of a "hard" detector do not differ as could be expected from those obtained from the measurements of complete fluxes. The differential cross-section of the formation of γ-quanta in the p–p collision (mass-centre system; angle 0 or 180°) was determined to be $(0{\cdot}59 \pm 0{\cdot}13) \times 10^{-27}$ cm^2/steradian; if the angular distribution of the mesons is isotropic their complete cross-section of formation for 670 MeV is $(3{\cdot}7 \pm 0{\cdot}8) \times 10^{-27}$ cm^2. This result and that obtained in the paper referred to above show that in the energy range 480–670 MeV, the cross-section varies as $p^{4{\cdot}5 \pm 0{\cdot}5}$ where p is the impulse of the π^0-meson. F. LACHMAN

539.18

9148. Production of charged π-mesons by nucleons. V. M. SIDOROV. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 6, 727–9 (1955) In Russian.

Cross-sections for production of π^+- and π^--mesons by protons of 657 MeV on carbon and for π^+-production by protons on hydrogen (contained in paraffin) are obtained. Carbon and liquid hydrogen targets are bombarded with neutrons produced by 670 MeV protons incident on beryllium. Energy distributions of the mesons are given. Mesons were detected in all cases by emulsions. G. E. BROWN

539.18

9149. On multiple production of mesons at energies 1–2·2 BeV. S. Z. BELEN'KIĬ AND A. I. NIKISHOV. Letter in *Zh. éksper. teor. Fiz.* **28**, *No.* 6, 744–6 (1955) In Russian.

Excited states of nucleons ($T = 3/2$, $J = 3/2$) are included in the Fermi theory of multiple production as new particles of mass 1·32 m. Results agree with the ratios of double to single production much better than in the Fermi theory. G. E. BROWN

539.18

9150. Multiple meson production in emulsions exposed to the bevatron beam. W. R. JOHNSON. Letter in *Phys. Rev.*, **99**, *No.* 3, 1049–50 (*Aug.* 1, 1955).

The size distribution of stars produced by protons of 3·2, 4·8 and 5·7 BeV is compared with that obtained by cosmic-ray work, in which the primary

particles are π-mesons and protons. The mean multiplicity is slightly lower for the bevatron stars, but in agreement with that predicted by the Fermi statistical theory. M. W. FRIEDLANDER

539.18

9151. Mesonic decay of a H_1^4 nucleus. Ö. HAUGERUD AND S. O. SÖRENSEN. Letter in *Phys. Rev.*, **99**, *No.* 3, 1046–7 (*Aug.* 1, 1955).

An event has been observed which can be interpreted as being of the form $H_1^4 \rightarrow He_2^4 + \pi^- + Q$ ($\simeq 55$ MeV). The kinetic energies and momenta of the product particles agree excellently with those in a similar event observed at Bristol. A. J. EGGINTON

539.181

9152. Scattering of fast neon atoms in neon gas. H. W. BERRY. *Phys. Rev.*, **99**, *No.* 2, 553–5 (*July* 15, 1955).

The angular distribution of fast neon atoms scattered by neon gas has been measured. The energies of the incident atoms ranged from 0·30 to 3·0 keV and the scattering was observed for angular deviations extending from 16 to 64° in the laboratory system. An interatomic potential was calculated from the measurements and may be represented for atom separations of 0·4 to 1·0 Å as $V(r) = 10{\cdot}4 \times 10^{-9} e^{-4{\cdot}25r}$ ergs (r in Å). The angular distribution of ions produced in the neutral atom collisions has also been measured. A.

539.181

9153. Velocity distributions in potassium and thallium atomic beams. R. C. MILLER AND P. KUSCH. *Phys. Rev.*, **99**, *No.* 4, 1314–21 (*Aug.* 15, 1955).

A high-resolution, high-intensity, spiral velocity selector has been designed for the study of the velocity distributions of the components of atomic and molecular beams. It has been found possible to design oven slits which closely approximate the ideal aperture of kinetic theory. An analysis has been made of the velocity distributions in beams of potassium and thallium over a range of velocity from 0·3 to 2·5 times the most probable velocity in the oven. The agreement between the observed distribution and that deduced, on the basis of the assumptions that the distribution in the oven is Maxwellian and that the aperture is ideal, is very good. A.

539.185

9154. Polarization of very fast neutrons on scattering at heavy nuclei. I. I. LEVINTOV. *Dokl. Akad. Nauk SSSR*, **98**, *No.* 3, 373–6 (1954) In Russian.

Fermi has shown [Abstr. 5705 (1954)] that the polarization of fast neutrons at nuclei, with a complex square-well potential and spin–orbit interaction, vanishes for no absorption and does not change sign as the scattering angle varies. These results were obtained on the Born approximation, and the author shows that they are brought about by the use of that approximation. Using the quasi-classical approximation for the scattering of fast neutrons ($\sim$300 MeV) at heavy nuclei of zero spin, the polarization is calculated and tabulated for lead. It is found to have neither of the properties mentioned above. J. B. SYKES

539.185

9155. Variation of diffusion length and thermal neutron absorption cross-section of graphite with temperature. J. E. C. MILLS. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. RP/R*1618, 13 *pp.* (1955).

The diffusion length and transport mean free path are measured as a function of graphite temperature. The variation of the derived thermal neutron absorption cross-section is compared with a $1/v$ law. A.

539.185

9156. Neutron–deuteron scattering in the range 80–200 keV. W. D. ALLEN, A. T. G. FERGUSON AND J. ROBERTS. Note in *Proc. Phys. Soc. A*, **68**, *Pt* 7, 650–4 (*July*, 1955).

Investigated by observing the recoils in a deuterium filled counter, the neutrons being produced by the p–T reaction. Interfering low energy γ-rays were reduced by backing the ZrT target with Ag instead of Cu, and by lead shielding around the target. Wall effects were corrected by making measurements with a hydrogen-filled counter also, and typical differential pulse-height distributions are given for both gases. It was found that the energy to produce an ion pair remained constant over the range 10–100 keV in hydrogen. A table is given of the n–p and n–d total cross-section measured. J. HUGHES

539.185 : 537.534.74

9157. A phase shift analysis of the scattering and polarization in neutron–proton collisions at high energy. C. A. KLEIN. *Nuovo Cimento* (*Ser.* 10) **2**, *No.* 1, 38–49 (*July*, 1955) In French.

Using the S and P phase shifts already determined from an analysis of the proton–proton interactions up to 330 MeV, a reasonable fit to the neutron–proton scattering and polarization is obtained in the 100 to 400 MeV region with the addition of ^3S, ^1P and ^3D phase shifts. P. T. MATTHEWS

539.185 : 537.534.74

9158. The scattering of nucleons by alpha particles—determination of the spin–orbit interaction. S. HOCHBERG, H. S. W. MASSEY, H. ROBERTSON AND L. H. UNDERHILL. *Proc. Phys. Soc. A*, **68**, *Pt* 8, 746–53 (*Aug.*, 1955).

The p-phases for the scattering of neutrons by α-particles have been calculated by the resonating group structure method assuming an interaction between nucleons of the form

$$V_0\{mM_{ij} + hH_{ij} + bB_{ij} + w + S\hbar^{-2}(\mathbf{s}_i + \mathbf{s}_j) \cdot \mathbf{r}_{ij} \times (\mathbf{p}_i - \mathbf{p}_j)\} \exp(-\beta r_{ij}^2) + (e^2/r_{ij})\epsilon_{ij},$$

where $\epsilon_{ij} = 1$ if the nucleons are protons and zero otherwise. M_{ij}, H_{ij} and B_{ij} are the normal Majorana, Heisenberg and Bartlett exchange operators, $\mathbf{s}_i$, $\mathbf{s}_j$ and $\mathbf{p}_i$, $\mathbf{p}_j$ are the spin and orbital angular momentum of the two nucleons. m, h, w, b are constants which satisfy the conditions $m + h + w + b = 1$, $m + w - (h + b) = x = 0{\cdot}6$. V_0 and β are taken to be -45 MeV and $0{\cdot}265\,7 \times 10^{26}$ cm^{-2} respectively. The parameter S measures the relative strength of the spin–orbit interaction, and the aim of the work was to determine S to give the best fit with the observed scattering data. It is found that the mean p-phase shift is only given correctly when the exchange operator in the central interaction is close to the Serber form $m = w = \frac{1}{2}(1 + x)$, $h = b = \frac{1}{2}(1 - x)$. A good fit is obtained with the following constants: $m = 0{\cdot}258 + 0{\cdot}325x$, $h = 0{\cdot}258 - 0{\cdot}325x$, $w = 0{\cdot}242 + 0{\cdot}225x$, $b = 0{\cdot}242 - 0{\cdot}225x$, $S = 0{\cdot}1$. The

phase shifts were calculated from the integro-differential equations using the Pilot ACE electronic computer. Values of the *d*-phases have also been obtained for neutron energies up to 16 MeV. A.

539.185 : 548.74

Thermal inelastic scattering of cold neutrons in polycrystalline solids. *See Abstr.* 9280

539.185.08

9159. A high-threshold scintillation detector of neutrons. P. S. Baranov and V. I. Gol'danskiĭ. *Zh. éksper. teor. Fiz.*, **28**, *No.* 5, 621–3 (1955) In Russian.

It is suggested that a high-energy neutron detector can operate on the basis of the reaction $C^{12}(n, 2n)C^{11}$, whose threshold is 20·2 MeV. The cross-section for this reaction is almost constant from 90 to 380 MeV. A block diagram of the apparatus is given, and experimental results on the removal of extraneous noise (due to cosmic rays, etc.) are discussed. J. B. SYKES

539.185.08

9160. Proton recoil fast-neutron spectrometer. I. Principles. B. R. Gossick. *Rev. sci. Instrum.*, **26**, *No.* 8, 754–6 (*Aug.*, 1955).

A general equation for calculating the neutron energy spectrum from proton recoil counting data is derived. This equation is optimized subject to a constant total error to determine the most favourable experimental conditions. Feasible accuracy is illustrated by presenting a family of curves of the counting time (required for one point of a spectrum) plotted against total error with source intensity as a parameter. The calculations apply only to a "good geometry" experiment with a point source. A.

539.185.08

9161. Proton recoil fast-neutron spectrometer. II. Experimental. R. G. Cochran and K. M. Henry. *Rev. sci. Instrum.*, **26**, *No.* 8, 757–62 (*Aug.*, 1955).

A triple-coincidence-type proton recoil spectrometer has been developed for measuring neutron spectra of reactors and artificial neutron sources. The instrument is composed of a triple-section proportional counter with suitable radiator-absorber wheels, amplifiers, electronic pulse-height selectors, and a triple-coincidence circuit. Considerable effort has been made to obtain maximum sensitivity by optimizing the radiator and absorber thicknesses and the counting times, and by minimizing the background effects. Under these conditions the energy resolution obtained approaches that obtained by photographic plates. The spectrometer was calibrated by measuring monoenergetic neutrons from the O.R.N.L. Van de Graaff generator. Typical examples of spectra measurements are included. A.

539.185.08 : 537.542

Flux measurements with the BF_3 "Long counter." *See Abstr.* 8852

539.185.08 : 778.34

9162. Measurements of neutronic dose by means of photographic plates. J. Catalá, J. Casanova and M. de la Cuadra. *An. Real. Soc. Espaň. Fis. Quím.*, **51**(A) *No.* 5–6, 149–54 (*May–June*, 1955) In Spanish.

These are given as from 10^8 to 10^{10} neutrons/cm^2. The methods used in reducing errors to less than 10% are described. Thermal neutrons produced the $N^{14}(n, p)C^{14}$ reaction in the plates. References to previous use of this reaction are given. J. J. Phipps

STRUCTURE OF SOLIDS 539.2

539.211

9163. Brittle fracture and yielding. A. N. Stroh. *Phil. Mag.*, **46**, 968–72 (*Sept.*, 1955).

The stresses round a piled-up group of dislocations may either initiate a crack or operate a Frank–Read source by pulling it from its locking impurities; the latter is related to the propagation of a Lüders band. This interpretation leads to results in accord with experiment. The model gives a sharp transition from brittle to ductile behaviour as the temperature is increased. A.

539.213.1

9164. Glass-forming materials. A. Winter. *Cahiers de Phys.*, *No.* 57–58, 10–22 (*May–June*, 1955) In French.

A fuller account of the idea that the glass-forming propensity of inorganic materials is mainly determined by the number of *p*-electrons per atom: four is the optimum number, while no glasses with less than two are known [see Abstr. 3155 (1955)]. In support of the thesis is a fully documented table giving all known binary glasses with O, Se, S or Te as one of the components. It includes about 20 new glasses whose existence was surmised by the author on the basis of her rules. R. O. Davies

539.213.1

9165. On the structure of vitreous silica. A. Winter. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 25, 2397–9 (*June* 20, 1955) In French.

Accurate measurements of the refractive index of vitreous silica as a function of temperature shows a series of small discontinuities in slope and/or ordinate at the known transition temperatures of all the crystalline forms of silica. This is taken to imply that small regions of all these crystalline forms are present in the vitreous state. W. M. Lomer

539.217

9166. Diffusion of zinc in zinc oxide. F. Münnich. Note in *Naturwissenschaften*, **42**, *No.* 11, 340–1 (1955) In German.

Crystals of ZnO were heated in active Zn vapour for a long time at temperatures 850–1 100°C. The surface was then progressively removed by etching to determine an activity *v.* depth curve. The profile did not fit a single diffusion curve; the results are presented in the form of apparent diffusion coeff. *v.* concentration at several temperatures. Variation of *D* with concentration of tracer may be a factor of thirty in some cases. W. M. Lomer

539.217

9167. Two-material films. V. Diffusion of silver in selenium. G. Kienel. *Ann. Phys.* [*Leipzig*] **16**, *No.* 1–2, 1–6 (1955) In German.

For Pt IV, see Abstr. 10552 (1954). Thin films of Se and Ag were evaporated on to glass substrates and the diffusion of the Ag along the film observed as a

function of time at 20°C. The diffusion length was not accurately proportional to the square root of time, which is interpreted as a variation of diffusion rate with thickness of film. W. M. LOMER

539.217

9168. Two-material films. VI. Electron diffraction investigations on diffusion phenomena in thin silver selenium sheets. U. ZORLL. *Ann. Phys.* [*Leipzig*] **16**, *No.* 1–2, 7–26 (1955) In German.

The intermetallic compound Ag_2Se when formed below 130°C has a low symmetry pseudo-cubic structure, and transforms above 130°C to a genuine body-centred structure, $a = 4{\cdot}978$ Å. Under some conditions a transformation from the low symmetry form to a rhombic form, (001) axis normal to the sheet, occurs. The lattice constants of this form are $a = 7{\cdot}046$, $b = 4{\cdot}325$, $c = 7{\cdot}82$ Å. W. M. LOMER

539.217

9169. Two-material films. VII. Interaction of residual mercury vapour on the diffusion of silver in thin sheets of tellurium or selenium. U. ZORLL. *Ann. Phys.* [*Leipzig*] **16**, *No.* 1–2, 27–30 (1955) In German.

Electron diffraction shows that Hg vapour from the diffusion pumps reacts with Te or Se to form HgTe or HgSe, both of which have the cubic zinc-blende structure with $a = 6{\cdot}429$ and $6{\cdot}074$ Å respectively. W. M. LOMER

539.217

9170. Effect of screening on solute diffusion. F. J. BLATT. Letter in *Phys. Rev.*, **99**, *No.* 2, 600–1 (*July* 15, 1955).

It is shown that the use of screening radii, calculated by Friedel's method, gives results for the activation energy of diffusion of elements of various valency in Ag which are in worse agreement with experiment than the use of Thomas–Fermi radii. A marked asymmetry between positive and negative valence differences is expected on the basis of the new calculation, and preliminary results of diffusion of Ru in Ag seem to confirm this. W. M. LOMER

539.26

9171. On the disarrangement and the cold recovery of aluminium crystals under low stresses. J. CAISSO AND R. JACQUESSON. *C.R. Acad. Sci.* [*Paris*] **241**, *No.* 1, 50–2 (*July* 4, 1955) In French.

The Guinier–Thénevin technique was used to investigate the small disorientations in Al crystals under stress. For small strains, $\varepsilon < 0{\cdot}2\%$ and the original crystal good, the disorientations decrease. This effect is most marked when the stress is about 300 g/mm²; after recovery at this stress the stress may be raised to 800 g/mm² before the disorientations increase. If the initial disorientations exceed 3′ of arc, the effect is not seen. As the strain increases to $1{\cdot}5\%$ a slow increase in disorientation is seen; above $1{\cdot}5\%$ the rate increases greatly and striations appear. Above $3{\cdot}5\%$ extension the broad spots resolve themselves clearly into distinct regions, corresponding to formation of reasonably perfect microcrystals.

W. M. LOMER

539.26

9172. Small particle X-ray scattering by fibers. II. Radial distribution of microcrystallites. A. N. J. HEYN. *J. appl. Phys.*, **26**, *No.* 9, 1113–21 (*Sept.*, 1955).

For previous part, see Abstr. 6547 (1955). Radial distribution functions of the microcrystalline particles in fibres are derived from the X-ray scattering at small angles. Particle distribution functions are obtained by application of the method of Fourier synthesis to the X-ray data, by inversion of the intensity scattered under conditions where inter-particle interference plays a part. Different distribution curves are obtained with different fibres, investigated under the same conditions. The distribution curves obtained with the same fibre investigated under different conditions of swelling, are consistent with the wider separation of the particles at higher degree of swelling. A quantitative explanation is thus given of the differences between the scattered intensities at different degrees of swelling. The degree of crystallinity is calculated from the distribution curves, so obtained, in combination with the particle sizes determined in preceding papers. A.

539.27

9173. On the estimation of the thickness of the Beilby layer. S. YAMAGUCHI. *Z. Phys.*, **140**, *No.* 6, 577–80 (1955) In German.

Surfaces of specimens of 15% chrome steel, Permalloy, and 18 : 8 stainless steel were polished mechanically in various ways and oxidized in a bath of molten $NaNO_3$–KNO_3. The stripped oxide film is about 150 Å thick, and its lower surface shows the underlying metal crystal structure in the electron microscope only if the Beilby layer is thinner than this. In 18:8 stainless steel the Beilby layer gives b.c.c. diffraction pattern and a direct comparison of intensity of b.c.c. to f.c.c. lines in a thin specimen gives a thickness 250 Å after mechanical polishing.

W. M. LOMER

539.27

9174. Observation of crystalline structures in a photoemission electron microscope. E. L. HUGUENIN. *C.R. Acad. Sci.* [*Paris*] **241**, *No.* 3, 307–9 (*July* 18, 1955) In French.

The examination of crystalline structures requires clean surfaces, free of any flowed layer. Substances of high melting point may be examined after single heat treatment. For materials of lower melting point, ionic bombardment is sometimes effective. Where this is insufficient, cathodic sputtering followed by ionic bombardment is used, and the crystalline structure is then clearly revealed.

A.E.I. RESEARCH LABORATORY

539.27 : 539.23

9175. The sensitivity of electron diffraction as a means of detecting thin surface films. I. R. C. NEWMAN AND D. W. PASHLEY. *Phil. Mag.*, **46**, 927–40 (*Sept.*, 1955).

Very thin layers (0–20 Å) of silver bromide and of copper have been deposited on to smooth (111) surfaces of silver single crystals. The thickness of these layers has been determined by means of a radioactive technique. The electron diffraction patterns from the layers have been studied as a function of their thickness. The layers do not grow as uniform films but as nucleated deposits. It is found that the thinnest detectable layer is 0·4 Å in mean thickness for the silver bromide and 0·8 Å for the copper. A.

539.27 : 539.232

9176. Electron micrographs from thick oxide layers on aluminium. C. J. L. Booker, J. L. Wood and A. Walsh. Letter in *Nature* [*London*] **176,** 222–3 (*July* 30, 1955).

Replication studies show that the thick anodized layers have a porous structure. The pores are aligned in parallel with their orientation normal to the layer surface. R. REED

ELASTICITY . STRENGTH . RHEOLOGY
539.3/.8

539.3

9177. Nomenclature of strain parameters. A. D. Fokker. *Physica,* **21,** *No.* 7, 575–8 (*July*, 1955).

One-dimensional, two-dimensional and three-dimensional strain parameters are defined. The last ones are an isotopic bulk dilatation $v = \ln(V'/V)$, a bulk shear strain ζ and a bulk shear modality χ characterizing the amount and the shape of deformation. It is shown how to find the parameters from the particle displacements u_i. A.

539.32

9178. The measurement of the dynamic elastic modulus and the viscosity of rubberlike materials using electronic apparatus. A. Betticher, V. Hardung and J. Maillard. *Helv. phys. Acta,* **28,** *No.* 4, 306–7 (1955) In German.

The dynamic constants are determined from the phase difference between the alternating stress and strain displayed on an oscilloscope using transducers. J. E. CAFFYN

539.32

9179. Dependence of the torsion modulus of steel on the torsional stress. L. Kopecký. Letter in *Czech. J. Phys.,* **5,** *No.* 2, 283–5 (*April*, 1955) In German.

It is found that for the types of steel used, Hooke's law is not obeyed though the difference is slight. Heat treatment and mechanical history of the steel have marked effects. T. C. TOYE

539.32

9180. The measurement of elastic wave velocity in small cylindrical specimens. N. B. Terry and H. J. Woods. *Brit. J. appl. Phys.,* **6,** *No.* 9, 322–5 (*Sept.*, 1955).

A modification of the composite oscillator method is described in which the specimens, which have sizes ranging down to 5 mm in length and $\frac{1}{2}$ mm across, are cemented to nickel wire transducers. By exciting the nickel rod magnetostrictively, the resonant frequency of the composite rod can be measured and the elastic wave velocity in the specimen calculated. The behaviour of the composite oscillator when the areas of cross-section of the components are not matched is discussed. The selection of a transducer for a particular specimen with the object of reducing the errors due to the cement and to inaccurate frequency measurement is considered. Some results of measurements on mineral and keratin specimens are given. A.

539.32 : 548.73

9181. The determination of the elastic constants of germanium by diffuse X-ray reflexion. S. C. Prasad and W. A. Wooster. *Acta Cryst.,* **8,** *Pt* 8, 506–7 (*Aug.*, 1955).

The elastic ratios c_{12}/c_{11} and c_{44}/c_{11} have been measured by the diffuse reflection of X-rays from a single crystal of germanium. The values obtained were respectively 0·38 and 0·52. When these results are combined with the already known cubic compressibility the elastic constants can be evaluated as $c_{11} = 13{\cdot}3$, $c_{12} = 5{\cdot}1$, $c_{44} = 7{\cdot}0 \times 10^{11}$ dyne cm^{-2}. A.

539.374 : 539.576

9182. Elastic–plastic instability caused by the size effect and its influence on rubbing wear. F. V. Hunt. *J. appl. Phys.,* **26,** *No.* 7, 850–6 (*July*, 1955).

The yield strength of many materials is much higher for minute specimens than for bulk samples. The region around the point of highest shear stress in a solid undergoing deformation by a small spherical indenter can be regarded as such a minute specimen which may be "protected" by the size effect against plastic yielding if it is small enough. Formulating the effective yield strength and the elastic stress under the indenter in terms of a common parameter provides a basis for assessing the influence of size scale on the plastic yield threshold. Four size categories are identified, including a critical case for which a small change of loading may cause a discontinuous transition from the elastic to the plastic régime throughout the region of contact, and another, more frequently encountered, in which the supportable pre-yield elastic stress is materially enhanced. The latter effect may exert an important influence on the rate of rubbing wear since it can make available a wider range of loading for which a low wear rate prevails. Reported wear tests on steel riders and on sapphire gramophone styli confirm these predictions qualitatively. A.

539.389.3

9183. Diffusion controlled stress relaxation. R. H. McMickle and E. T. Kubu. *J. appl. Phys.,* **26,** *No.* 7, 832–8 (*July*, 1955).

The action of water solutions of dimethyl formamide on Dinitrile A fibres was studied using the stress-relaxation technique. After prior conditioning and stress relaxation in water, the addition of dimethyl formamide–water solutions produced an exponential stress relaxation. It was found that the rate and extent of stress relaxation in dimethyl formamide–water solutions is dependent on the dimethyl formamide concentration. The rate of stress relaxation in dimethyl formamide–water solutions is also dependent on the cross-sectional area and the state of orientation of the fibre. These data can best be explained by postulating that the rate of diffusion of the dimethyl formamide–water solution into the fibre, controls the rate of stress relaxation. The diffusion coefficient is found to be concentration dependent, and the diffusion process has an activation energy of 14 kcal. A.

539.4

9184. Alloys for use at high temperatures. W. Betteridge. *Brit. J. appl. Phys.,* **6,** *No.* 9, 301–6 (*Sept.*, 1955).

The properties necessary in metallic materials intended for service at high temperatures are outlined and the characteristics of nickel-base alloys for such

applications are particularly described. The materials are dealt with in two classes: those primarily of value because of their resistance to oxidation and those characterized by high strength at elevated temperatures. A.

539.4.015

9185. The strength of single crystal and polycrystalline corundum. E. A. JACKMAN AND J. P. ROBERTS. Letter in *Phil. Mag.*, **46**, 809–11 (*July*, 1955).

Specimens of length 58 mm and with a square cross-section of side 2 mm were tested in flexure to compare the tensile strength of corundum single crystals made by the Verneuil method with that of dense sintered corundum material at temperatures up to 1 300°C. The strength of the polycrystalline material remained constant up to 700°C and then decreased slowly with increasing temperature. That of the single crystals showed a pronounced minimum and the values varied among the rods from which the specimens were machined. There was no connection between the strength-temperature characteristics and the orientation of the single crystals. It was concluded that the polycrystalline material fractures in an intercrystalline manner at room temp. because the single crystals were stronger. Between 300 and 600°C the crystals in the polycrystalline material were stronger than the large single crystals, while intercrystalline fracture was common above 1 000°C. A. C. WHIFFIN

539.4.016 : 537.311.31 : 538.639

9186. Specification of thermally and mechanically induced nonequilibrium states in AuCu by the resistivity and magnetoresistivity. B. WIENER, G. GROETZINGER AND R. MCCOLLUM. *J. appl. Phys.*, **26**, *No.* 7, 857–62 (*July*, 1955).

Studies were made of the change in the resistivity and magnetoresistivity of samples of AuCu, which had been thermally disordered, while annealed at 150°C, of samples, completely disordered by cold work, while annealed at 150 and 265°C, and of initially ordered samples when subjected to varying amounts of cold work. The curves of magnetoresistivity against resistivity for the last three cases agree with one another, but differ from that for the thermally disordered sample annealed at 150°C and from a previously obtained curve for the annealing of a thermally disordered sample at 265°C. These last two curves are also markedly different from each other. All five curves appear distinct from the previously obtained curve for AuCu in equilibrium. An interpretation of the results in terms of the production of a more or less pronounced admixture of AuCu II during certain stages of the cold working or annealing process is presented. A.

539.42 : 541.64

9187. Tensile strength of plastics above the glass temperature. F. BUECHE. *J. appl. Phys.*, **26**, *No.* 9, 1133–40 (*Sept.*, 1955).

A theory is presented for the tensile strength of rubbery plastics under dynamic test conditions. It is found that a nearly universal curve may be plotted relating the tensile strength of rubbers to the time of application of the load in a simple creep test or to the shear rate in a conventional type tensile test. The dependence on chain length, degree of cross linking, and temperature is also predicted. Experimental results for the tensile strength of poly butyl methacrylate in the range 30–95°C are presented. These are shown to agree with the theory within the experimental error. The experimental testing scale extends over a range of eight decades when use is made of a temperature–time superposition principle predicted by the theory. By comparing the tensile creep and tensile strength curves for poly butyl methacrylate, it is possible to find the size of a segment as defined in the theory of viscoelasticity. One segment is found to contain about six monomer units. A.

539.431

9188. A stress-strain machine for testing single crystals in alternating tension and compression. M. S. PATERSON. *J. sci. Instrum.*, **32**, *No.* 9, 356–9 (*Sept.*, 1955).

A testing machine in which special precautions are taken to eliminate external bending or torsion of the specimen. The load and extension gauges are of the roller and mirror type for high sensitivity. The difficulty of gripping a single crystal firmly without damaging it is overcome by using a chuck in the form of a mould, into which the crystal is cast with solder. Examples of the performance of the machine are given. A.

539.434

9189. Application of the superposition principle and theories of mechanical equation of state, strain, and time hardening to creep of plastics under changing loads. W. N. FINDLEY AND G. KHOSLA. *J. appl. Phys.*, **26**, *No.* 7, 821–32 (*July*, 1955).

The superposition principle and the theories of mechanical equation of state, strain and time hardening are applied to the creep under changing loads of four unfilled thermoplastics—polyethylene; monochlorotrifluoroethylene (Kel-F), crystalline; polyvinylchloride (Geon-404), annealed; and polystyrene. A comparison of the theoretical results predicted by these theories with the experimental results indicates the accuracy with which these theories described the creep behaviour under changing loads for the above materials. A.

539.501

9190. Viscosity and elasticity of oil surfaces and oil-water interfaces. D. W. CRIDDLE AND A. L. MEADER, JR. *J. appl. Phys.*, **26**, *No.* 7, 838–42 (*July*, 1955).

A study of the rheological properties of lubricating oils was made by means of semiquantitative measurements of the viscosity and elasticity of surface and interfacial films. A torsion-pendulum type, surface viscometer was used. A refined, uncompounded mineral oil was shown to possess neither surface nor interfacial viscosity or elasticity. One additive in mineral oil showed surface viscosity and elasticity, and two additives developed these properties at an oil-water interface. The aged, viscous surface and interfacial films studied were found to be non-Newtonian. A.

539.501

9191. An apparatus for measuring the visco-elastic properties of coal in the course of carbonization. D. FITZGERALD. *J. sci. Instrum.*, **32**, *No.* 9, 359–61 (*Sept.*, 1955).

The apparatus, which allows the strain-time relationship for a briquette upon application and

removal of a sudden stress to be observed, shows that an increasing viscosity is accompanied by an increasing elasticity which is retarded. Constructional details are given, with the results of one representative experiment. The possible application of the apparatus to studies of stresses and cracking in coke oven charges is indicated. A.

539.531

9192. On the hardness of glass surfaces. E. BRÜCHE AND G. SCHIMMEL. *Z. angew. Phys.*, **7**, *No.* 8, 378–85 (1955) In German.

An account of hardness tests carried out on five commercial glasses by means of a diamond-pointed micro-scriber. A full explanation is given of how the instrument is to be used in order to get reproducible and communicable results. R. O. DAVIES

539.531 : 548.0

9193. Directional hardness studies on single crystals of tin and bismuth. S. TOLANSKY AND A. P. WILLIAMS. *Proc. Phys. Soc. B*, **68**, *Pt* 8, 548–58 (*Aug.*, 1955).

With the use of a double-cone diamond indenter, directional hardness studies are made on virgin surfaces of cast single crystals of Sn and Bi. The crystallographic orientations are determined by X-rays. Surface flow effects associated with the indenter are studied by multiple-beam interferometry. Hardness variations are measured over a 180° orientation range on each surface studied and they depend on the particular crystal face indented. Thus on a tin (311) face the ratio of maximum to minimum hardness goes through the range 1·6 : 1 whilst on a (554) face of bismuth the range is as great as 4·5 : 1. It is demonstrated by interferometry that slip mechanism plays a primary part in producing directional variations in hardness. A.

539.576 : 539.16.08 : 778.33

9194. Investigation of the wearing resistance of cutting tools by the method of radioactive isotopes and irradiation. N. F. KAZAKOV. *Izv. Akad. Nauk SSSR, Otdel. tekh. Nauk*, *No.* 1, 41–53 (1954) In Russian.

An investigation carried out with various kinds of cutter and various working materials, with various cutting parameters (speed, depth and feed) is described. It is shown that the method of irradiating the cutters before use and then measuring the radioactivity of the turnings, etc., can be made completely safe and is very much more rapid than the ordinary methods of weighing, micrometry, etc. This enables a considerable range of cutting conditions to be investigated with a single cutter. The isotopes used are those of tungsten, titanium and cobalt. A description is given of the radiographic method of investigating the results of wearing. In this, the turning or the worked material is placed in contact with a photographic plate, the exposure time being several days. When the plate is developed, the position and extent of the radioactive cutter wearing products are easily seen. Accurate photometry of such plates would give a quantitative estimate of wearing. Numerous figures and tables are given to illustrate the results, and future applications of the method are indicated. J. B. SYKES

539.58

9195. Preliminary results in measuring dynamic compressibilities. W. PHILIPPOFF AND J. BRODNYAN. *J. appl. Phys.*, **26**, *No.* 7, 846–9 (*July*, 1955).

In order to supplement dynamic measurements in shear and bending, a vibration tester was used to measure the bulk compressibility of plastics using harmonic vibrations. Polyethylene and plasticized polyvinyl chloride were investigated. The values of the compressibility were comparable to the static values as far as they are known. A noticeable phase shift between pressure changes and volume changes could not be detected with certainty so that the bulk modulus B in dynes/cm^2 is not a complex quantity. Especially for the polyethylene, a temperature range from −25 to +95°C and a frequency range from 0·000 3 to 5 c/s was used. The isothermals obtained could be shifted together using the method of reduced variables of Ferry. From the frequency shifts a_T, an activation energy of 60 kcal/mole was obtained. A.

539.61 : 537.221

Adhesion and charging of quartz surfaces. *See Abstr.* 8726

539.62

9196. The relation between friction and wear for boundary-lubricated surfaces. E. RABINOWICZ. *Proc. Phys. Soc. B*, **68**, *Pt* 9, 603–8 (*Sept.*, 1955).

A relationship between friction and mechanical wear for lubricated surfaces is derived in the form $Z^{2/3} = k(f - f_1)$ where Z is the wear per unit sliding distance, f the friction coefficient, and k and f_1 are constants. Experiments are described in which the metal transfer and the loose wear were measured, and satisfactory agreement with the derived equation obtained. A.

539.62

9197. Deformation properties of friction junctions. J. A. GREENWOOD AND D. TABOR. *Proc. Phys. Soc. B*, **68**, *Pt* 9, 609–19 (*Sept.*, 1955).

Describes an experimental investigation of the mechanism of sliding friction by shearing large-scale models of friction junctions under conditions where no normal displacements are allowed. This condition, as Green first pointed out [Abstr. 3203 (1955)], must hold in steady sliding. Experiments have been performed simulating the cases of very strong adhesion, weak adhesion and lubricated sliding with very little adhesion. The results are in good qualitative agreement with the theoretical solutions obtained by Green using the theory of plasticity. For very strong adhesion the models yield average values of μ in the range 3–10. Coefficients of friction of the order $\mu = 1$ are only obtained for weak adhesion. This suggests that the value observed for clean metals sliding in air ($\mu = 1$) results from the presence of oxide or contaminant films. Results for lubricated junctions, where adhesion is negligible, suggest that in lubricated sliding, plastic deformation of the sliding metals may contribute an appreciable part of the observed friction even when there is no actual penetration of the lubricant film. A.

539.62 : 537.311.4

9198. The contact resistance and mechanical properties of surface films on metals. R. W. WILSON. *Proc. Phys. Soc. B*, **68**, *Pt* 9, 625–41 (*Sept.*, 1955).

The nature of the contact between sliding metal surfaces has been investigated by measuring the

electrical contact resistance and the coefficient of friction between them. Observations were made over a wide range of conditions which extended down to very light loads of only a few milligrammes so that the influence of surface films might be studied. Many noble and base metals have been investigated in both clean and lubricated states. The contact between certain typical pairs of dissimilar metals has also been studied. It was found that at loads below a few grammes the oxide film on base metals prevented actual metal-to-metal contact almost entirely. At higher loads the film was disrupted, and metallic contact occurred. The change from oxide-on-oxide to metal-on-metal sliding was usually accompanied by changes in the coefficient of friction, the nature of the sliding, and the appearance of the track. The same techniques have been used to investigate the influence of the Beilby layer, by comparing the behaviour of annealed and electropolished surfaces with that of worked ones. The contact between lubricated metals has also been studied over a wide range of loads and the electrical contact measurements have shown that with monobasic fatty acids a change in the nature of contact occurred as the load was increased. It was found that at heavy loads the contact resistance between lubricated metals fell to a value comparable with that of clean surfaces although measurements of the coefficient of friction suggested that the area of actual metallic contact had not increased correspondingly. These experiments have shown that the behaviour of oxide, Beilby and lubricant films on metal surfaces follow the same pattern, and that a single general picture, based on the theory of the sliding between clean metals at heavy loads, can be given which will describe their influence on the contact and sliding between metals. A.

539.621

9199. Friction of Teflon sliding on Teflon. D. G. Flom and N. T. Porile. *J. appl. Phys.*, **26**, *No.* 9, 1088–92 (*Sept.*, 1955).

The low coefficient of friction for Teflon sliding on Teflon, as observed previously by others, has been found to hold only if low sliding speeds and newly prepared surfaces are used. At high sliding speed, the nature of the surface is irreversibly changed such that subsequent sliding at low speed reveals a two- to threefold increase in the friction coefficient. In addition to the effect of high speed sliding, there are reversible changes in the friction of Teflon-on-Teflon dependent in part on temperature. As the temperature of Teflon is increased from below room temperature, a sharp and pronounced increase in the coefficient of friction is observed in the vicinity of 20°C. The existence of a phase transition in Teflon at this temperature indicates a close correlation between the frictional and the structural properties of this material. A.

PHYSICAL CHEMISTRY 541

PHASE EQUILIBRIUM . CHEMICAL REACTIONS 541.11/.12

541.123.2

9200. On the dissociation energies of SrO and MgO molecules. R. F. Porter, W. A. Chupka and M. G. Inghram. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1347–8 (*July*, 1955).

The partial pressures of the gaseous species in equilibrium with the solids, SrO and MgO, in an alumina Knudsen cell at about 2000°K were determined mass-spectrometrically and the dissociation energies of the (gaseous) oxide molecules calculated. The results for the system SrO are interpreted as showing that solid SrO vaporizes mainly by decomposition to gaseous Sr and oxygen and not as SrO.

W. GOOD

541.123.5

9201. Simplified calculation of isotopic exchange half-time. L. R. Darbee. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1349 (*July*, 1955).

It is shown how the calculation of the time of half change can be simplified by the use of an alignment chart constructed by the standard methods of nomography. The procedure is considered in detail for the reaction $CX^* + DX_2 \rightleftharpoons CX + DX_2^*$.

W. GOOD

541.124

9202. Gas phase oxidation of formaldehyde. M. D. Scheer. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1357–8 (*July*, 1955).

The quantitative facts about the gas phase oxidation of formaldehyde in the region 300–400°C are listed and interpreted by assuming that performic acid is formed by a simple homogeneous free radical chain mechanism with HCO and HCO_3 as chain carriers.

W. GOOD

541.124

9203. Observation of the semiquinone of benzoquinone. S. Blois. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1351 (*July*, 1955).

The semiquinones of *o*- and *p*-benzoquinone have been observed with a paramagnetic resonance spectrometer. A reaction scheme for the alkaline oxidation-reduction of benzoquinone is given. The maximum free radical concentrations were found to be of the order of 10^{-5}M.

C. TURNER

541.124

9204. Reaction of oxygen atoms with ethylene. R. J. Cvetanović. *J. chem. Phys.*, **23**, *No.* 8, 1375–80 (*Aug.*, 1955).

Reaction of O-atoms, produced by mercury photosensitized decomposition of nitrous oxide, with ethylene has been studied at room temperature and 123°C. The primary step of the process appears to be a direct addition of the atom to the double bond to form an energy-rich intermediate which undergoes further reactions. The following products are formed: aldehydes (CH_3CHO, C_2H_5CHO and C_3H_7CHO), CO, CH_4, C_2H_6, C_3H_8, C_4H_{10}, H_2, very small amounts of some other substances and traces of HCHO. At 24°C O-atoms react with ethylene 22 ± 5 times as readily as with *n*-butane. Assuming comparable

pre-exponential factors for the two processes $\Delta E = -1{\cdot}9$ kcal/mole, so that the activation energy of addition of oxygen atoms to the double bond in ethylene is estimated at close to 3 kcal/mole. In the presence of molecular oxygen the character of the reaction is profoundly changed. A.

541.124

9205. Rates of isotopic reactions between methyl and hydrogen. J. C. POLANYI. *J. chem. Phys.*, **23**, *No.* 8, 1505–13 (*Aug.*, 1955).

The absolute rate calculations made by Eyring and collaborators on the series of eight isotopic reactions $H + H_2$, etc., fail to provide a real test of their method, Recent data on the eight reactions $CH_3 + H_2$, $+HD$. $+DH$, $+D_2$; $CD_3 + H_2$, $+HD$, $+DH$, $+D_2$, provide the first set of independent observations on a series of simple isotopic exchange reactions. Detailed calculation of the entropies of activation give values for the temperature independent factors $A_{\text{calc}}^{400^\circ\text{K}}$. The energy surface for the reactions is calculated according to the method of Gorin, Kauzmann, Walter and Eyring in conformity with the H.L.S.P. treatment of methane. The surface obtained, $E = f(\omega, r, s)$, has a single barrier indicating a classical activation energy of ~13 kcal for the forward reaction, in adequate agreement with observed values. The surface described is, therefore, the "best semi-empirical surface"; the height of the barrier being regarded as a calibrated, not a predicted, quantity. The surface is accordingly made the basis for a calculation of the total zero-point energies of the eight reactions in their initial states and transition states. Substantial differences in activation energy are predicted. However, rate constants calculated on this basis show no correlation with observation; indicating failure of the method. Using a differently calibrated surface, designed to give the lowest barrier height compatible with a surface free of energy basins, a "symmetrical" surface is obtained for the present series of reactions. Zero-point energies derived from this surface lead to relative rate constants in fair agreement with the eight observed values. This correlation is more properly described as a correlation between A_{calc} and k_{obs}, and is discussed on this basis. A.

541.127

9206. Reaction of methyl radicals with methane and ethane. M. H. J. WIJNEN. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1357 (*July*, 1955).

Experimental results are given for the reaction of CD_3 radicals with C_2H_6 and CH_4. The activation energy of the former is found to be $11{\cdot}2 \pm 0{\cdot}3$ kcal. The radicals react about 8 times as fast with C_2H_6 as with CH_4. Assuming the steric factor to be approx. the same for both a value of 13 kcal. was calculated for the reaction with CH_4. W. GOOD

541.127

9207. The thermal decomposition of nitrous oxide. I. Secondary catalytic and surface effects. F. J. LINDARS AND C. HINSHELWOOD. *Proc. Roy. Soc. A*, **231**, 162–78 (*Aug.* 22, 1955).

In the region of pressure 0 to 500 mm the thermal decomposition of nitrous oxide conforms approximately to the equation $k = an/(1 + a'n) + bn$, where k is the formal first-order rate constant, $-(1/n)\,dn/dt$, n the initial concentration and a, a' and b are nearly constant. Above about 100 mm this expression approximates to $k = A + bn$, which holds up to several atmospheres. Fresh and more detailed experiments have once again disproved the suggestion that the first term in these expressions is due to a surface reaction. (In certain states of reaction vessels, made of a particular brand of silica, a surface reaction may appear but is immediately recognizable by special criteria, and can be eliminated.) Detailed study of the formation of nitric oxide in the course of the decomposition, and of the effect of inert gas upon this process, shows that side reactions involving oxygen atoms, chain reactions and catalysis by nitric oxide play only minor parts in determining the shape of the k–n curve. The form of this curve, which is an inherent character of the reaction $N_2O = N_2 + O$, raises theoretical questions of considerable interest. A.

541.127

9208. The thermal decomposition of nitrous oxide. II. Influence of added gases and a theory of the kinetic mechanism. F. J. LINDARS AND C. HINSHELWOOD. *Proc. Roy. Soc. A*, **231**, 178–97 (*Aug.* 22, 1955).

The influence of foreign gas additions (argon, nitrogen, carbon dioxide, carbon tetrafluoride and mixtures of them) on the thermal decomposition of nitrous oxide at a series of different initial pressures has been studied. The curves of k, the formal first-order constant, as a function of x, the foreign-gas pressure, show regions of rapidly falling slope analogous to those found in the curves of k against n, the initial pressure of nitrous oxide. The forms of the curves have been investigated in some detail, and suggest very strongly the existence of potentially rate-determining processes other than those normally assumed in unimolecular reactions (which are energization of molecules in collisions and chemical decomposition of these molecules). It is now postulated that spontaneous and collision-induced transfers of energized nitrous oxide molecules to triplet states constitute the processes in question, and on this basis the forms of the k, n and k, x curves are interpreted. This postulate links up with certain spectroscopic considerations previously advanced by Herzberg. A.

541.127 : 531.787

A sensitive manometer for rapid chemical reactions. *See Abstr.* 8528

541.127.1

9209. Rate of the gaseous reactions, $X^+ + YH = XH^+ + Y$. D. P. STEVENSON AND D. O. SCHISSLER. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1353–4 (*July*, 1955).

A preliminary report is given of studies of the collision cross-sections of some reactions of this type. Specific rate constants are tabulated. W. GOOD

541.128

9210. Effect of crystal orientation on the activation energy for the catalytic decomposition of formic acid on silver. H. M. C. SOSNOVSKY. *J. chem. Phys.*, **22**, *No.* 8, 1486–90 (*Aug.*, 1955).

Single crystalline sheets of silver have been used as catalysts for the decomposition of formic acid. The activation energy for the zero-order reaction was

found to vary from 16·0 kcal/mole with a crystal face close to {111} to 30·4 kcal/mole with a crystal face close to {110}. A.

ELECTROCHEMISTRY 541.13

541.13

9211. Electron theory of metals and hydrogen overvoltage. P. Rüetschi and P. Delahay. Letter in *J. chem. Phys.*, **23**, *No.* 6, 1167–8 (*June*, 1955).

A brief description is given of various treatments (to be published later) which show how hydrogen overvoltage (or exchange current) can be correlated with various quantities, such as work function, lattice constant, electronegativity, characterizing the metal. W. GOOD

541.132

9212. Ionized metal water. K. Murakoshi and J. Ohkawa. *J. Inst. Elect. Engrs Japan*, **74**, *No.* 4, 396–402 (*April*, 1954) In Japanese.

A method of dissolving metal ions by means of the sole medium of water. A glass tube filled with water and fitted with a porous-tissue membrane has a pos. Zn electrode. The whole is partially immersed in a water reservoir forming the neg. electrode. At first O_2 and H_2 are formed and then the Zn starts dissolving, the concentration of O_2 falling at the same time. The water in the reservoir becomes alkaline but returns to normal in due course. The metal water is stable and chemically neutral. The metal water is useful in biochemistry. H. G. M. SPRATT

541.133.1

9213. Self-diffusion of ions in molten electrolyte under the influence of an electric field. L. Yang and M. Simnad. *J. chem. Phys.*, **23**, *No.* 7, 1295–8 (*July*, 1955).

By taking into account both self-diffusion and electric migration of the radioactive ions formed by the electrolytic dissolution of a radioactive metal anode, an equation has been derived for the distribution of the radioactivity as a function of the distance from the anode surface along the diffusion path. Based on this equation, the error involved in the direct determination of ionic mobility by measuring the distance of spreading of the radioactivity and neglecting the rôle of self-diffusion is analysed. It is shown that for a system with a given diffusivity, the error decreases with the increase of the time of electrolysis, t, and the applied potential, E. To obtain the true ionic mobility, it is suggested that measurements should be made for a number of "t" or "E" values. The apparent ionic mobility obtained is then plotted against $1/t$ or $1/E$ and extrapolated to $1/t = 0$ or $1/E = 0$ to give the true value. A.

541.135.4 : 548.7

9214. Ionic conductance of some solid metallic azides. P. W. M. Jacobs and F. C. Tompkins. *J. chem. Phys.*, **23**, *No.* 8, 1445–7 (*Aug.*, 1955).

Measurements of the ionic conductance of several metallic azides have shown an unusually low activation energy for the structure-sensitive conductance in potassium, calcium and strontium azides. This is here associated with the mobility of surface lattice defects. A.

PHOTOCHEMISTRY . RADIATION CHEMISTRY 541.14/.15

541.14

9215. Photochemical studies of the porphyrins. III. Photoreduction of a porphyrin by benzoin. G. R. Seely and M. Calvin. *J. chem. Phys.*, **23**, *No.* 6, 1068–78 (*June*, 1955).

An examination of the kinetics of the photoreduction of zinc tetraphenylporphin by benzoin is reported. The products are successively the dihydro-(chlorin) derivative; a tetrahydro-derivative and possibly a hexahydro compound as well. It is demonstrated that the primary requirement is the photoactivation of the benzoin; a secondary reaction, involving photoactivated porphyrin as well, is also demonstrated. The quantum yield based on light absorbed by benzoin varies between 0·01 and 0·06. A.

541.15

9216. Radiation chemistry of solutions. M. Ebert and P. Howard-Flanders. *Nature* [*London*] **176**, 197–8 (*July* 30, 1955).

Brief report of a conference held by the Société de Chimie Physique in Paris, May 31–June 3 (1955).

DISPERSIONS . COLLOIDS . ADSORPTION 541.18

541.182.025

9217. Sedimentation thixotropy and laminar coagulation: separate forms of bulk phase and surface coagulation. N. F. Yermolenko. *Disc. Faraday Soc.*, *No.* 18, 145–50 (1954).

A survey of recent quantitative work on thixotropy carried out in Russia. In particular, some details are given of investigations where measurements on shear strength, modulus of elasticity, elastic after-effect and relaxation have been made. The importance of the study of foams and emulsions is stressed. J. IBALL

541.182.5

9218. Stress relaxation, birefringence and the structure of gelatin and other polymeric gels. A. V. Tobolsky. Note in *J. phys. Chem.*, **59**, *No.* 6, 575 (*June*, 1955).

Although there is a strong likelihood that gels of polycrystalline polymers are held together by crystallites acting as crosslinks, the author, after reference to other work [Stein and Tobolsky, *Textile Research Journal*, **18**, 302 (1948); *ibid.*, **19**, 8 (1949); Stein, Holmes and Tobolsky, *J. Polymer Sci.*, **14**, 443 (1954); Miller, Ferry, Schremp and Eldridge, *J. phys. Chem.*, **55**, 1387 (1951)], suggests that the mechanism for the relaxation of gelatin gels may not be correct. Part of the stress decay could be due to further growth of oriented crystalline material. H. G. JERRARD

541.182.5 : 541.64

9219. Gel formation by main-chain fracture of long-chain polymers. A. CHARLESBY. *Proc. Roy. Soc. A*, **231**, 521–34 (*Sept.* 20, 1955).

The conditions are examined under which the fracture of main-chain bonds in a long-chain polymer, which would normally result in a decrease in average molecular weight, can nevertheless result in formation of a network of infinite extent (gel). It is assumed that the two end-groups produced at a fractured site can attack neighbouring molecules, and link themselves to them. For an initially random distribution it is shown that gel formation will first occur when one molecule in three is thus fractured. The sol fraction is found to equal $(i/3r)^2$, where r/i is the average number of fractures per molecule; with increasing fracture density the sol therefore tends to zero. Where only a proportion of the fractures result in linking, the sol fraction decreases to a limiting value. Expressions are derived for many of the parameters of the sol and gel fractions and for the swelling. The results obtained are compared with those for crosslinking of polymers with a similar molecular weight distribution. To distinguish the process considered in this paper from that usually referred to as crosslinking, the term endlinking is proposed. A.

541.183

9220. Chemical and physical adsorption on solid oxides and hydroxides. J. J. KIPLING AND D. B. PEAKALL. *Research* Correspondence, **8**, *No.* 6, S 31–S 32 (*June*, 1955).

The criterion for the occurrence of chemisorption is that desorption shall fall below a measurable rate while leaving a substantial amount of the adsorbate on the surface. Even in reversible adsorption, however, complete desorption may take many, e.g. 100, hours. Data are given for silica and alumina.

S. J. GREGG

541.183.022 : 535.514.2

Optical study of monomolecular layers of haemin. *See Abstr.* 8663–4

CHEMICAL STRUCTURE 541.2/.6

541.553 : 539.132

9221. The quantum-theoretical bases of directed valence. K. ARTMANN. *Z. Phys.*, **141**, *No.* 4, 445–62 (1955) In German.

The criteria of maximum overlapping and orthogonality of the valence electrons are rejected. Instead an idealized larger molecule is treated in which all bonds retain directions but are relaxed. For this model it is postulated that the direction of the outer atoms is identical with that in which the central valence electrons assume maximum density probability. J. JACOBS

541.64 : 532.7

Intrinsic viscosity–molecular weight relationship of high polymers. *See Abstr.* 8543

CHEMICAL ANALYSIS 543/545

545.822

9222. On a spectrochemical method for analysis of radioactive solutions. J. HAALAND. *JENER Rep.*, *No.* 36, 9 *pp.* (1955).

545.822

9223. Use of sliding sparks for spectrum analysis in the far ultraviolet. Possibility of detection and estimation of sulphur, phosphorus and carbon in steels. G. BALLOFFET AND J. ROMAND. Letter in *J. Phys. Radium*, **16**, *No.* 6, 490–1 (*June*, 1955) In French.

With the source described in Abstr. 8585 (1955), and using lines in the range 900–1 200 Å, the limit of detection is 0·005% approx. G. F. LOTHIAN

545.824 : 535.33 : 537.531

X-ray emission spectrography using ion exchange membranes. *See Abstr.* 8807

CRYSTALLOGRAPHY 548

548.25

9224. Mixed crystal formation in the $A^{III}B^{V}$ compounds. O. G. FOLBERTH. Note in *Z. Naturforsch.*, **10a**, *No.* 6, 502–3 (1955) In German.

Crystals of the systems InAs–InP and GaAs–GaP series can be grown, and the energy gap has been followed part way through each system. In the InAs–InP series ΔE appears to vary linearly with composition from 0·33 to 1·25 eV, while in the GaAs–GaP system the variation is slow near GaP, at $\Delta E = 2{\cdot}25$ eV, but steepens towards GaAs at $E = 1{\cdot}45$ eV. Hall constant measurements in the InAs–InP series allow the mobilities of electrons to be determined as dropping smoothly from 2×10^4 cm^2/Vsec in InAs towards 3×10^3 cm^2/V sec in InP. W. M. LOMER

548.5

9225. Growth of iron whiskers. A. W. COCHARDT AND H. WIEDERSICH. Note in *Naturwissenschaften*, **42**, *No.* 11, 342 (1955).

Filaments, up to 2 in. long, mostly straight and of square cross-section but some consisting of straight parts with sharp bends between, are reported to grow from the ionic metal salt when crystals of sublimated anhydrous ferrous chloride are reduced in a hydrogen atmosphere at temperatures between 500–650°C. One whisker was shown, by X-rays, to be body-centred-cubic iron with its axis parallel to the [100] direction and with (100) planes as its sides. S. WEINTROUB

548.5

9226. Mechanism of the surface oxidation of copper. M. MATYÁŠ. *Czech. J. Phys.*, **5**, *No.* 2, 214–24 (*April*, 1955) In German.

New experiments on the oxidation rate of copper between 300 and 550°C are reported. These results are combined with those of other authors, and five temperature ranges are distinguished, each displaying different growth laws. At low temperatures (<250°C) and above 1030°C the film is Cu_2O, while between 300 and 1 000°C it is Cu_2O with an outer layer of CuO. With different diffusion coefficients in the two

layers sharp changes in activation energy with temperature are explained. W. M. LOMER

548.5

9227. The initial oxidation of nickel. U. M. MARTIUS. *Canad. J. Phys.*, **33**, *No.* 8, 466–72 (*Aug.*, 1955).

Under suitable experimental conditions small isolated crystallites are formed prior to the occurrence of a continuous oxide film. The shape, size and number of the crystallites depends on the crystallographic orientation of the underlying metal. The specific features of the oxidation of grain boundaries are discussed and a tentative explanation of the observed phenomena is advanced. A.

548.5

9228. The temperatures attained at the surfaces of growing deposits, and the origin of stress in deposits. H. WILMAN. Letter in *Proc. Phys. Soc. B*, **68**, *Pt* 7, 474–6 (*July*, 1955).

It is concluded, from electron diffraction measurements of crystal size and preferred orientation, that the surface mobility of certain electrodeposited metals and condensed oxide deposits is such that the surface temperature must be above the recrystallization temperature (e.g. 530–600°C for Ni, 650°C for anodic γ–Al_2O_3). J. THEWLIS

548.5

9229. Orientation of single-crystal silver halides by epitaxy. S. ZERFOSS AND J. W. DAVISSON. Letter in *Science*, **122**, 31–2 (*July* 1, 1955).

A method for observing the orientation of boules of AgCl and AgBr by epitaxy of NaCl on their surfaces is briefly described. The boule is immersed in an aqueous solution of NaCl which is allowed to evaporate slowly over several days when the boule acquires a coating of 0·1–2 mm NaCl cubes in close parallel-growth arrangement. S. WEINTROUB

548.5

9230. An occasional mode of growth in diamond. S. TOLANSKY AND S. H. EMARA. *Proc. Phys. Soc. B*, **68**, *Pt* 8, 559–61 (*Aug.*, 1955).

It is shown that in rare instances a mode of growth by plane sheets operates on the octahedral faces of diamond which leads to the formation of six-sided growth features containing alternate angles of approximately 90 and 150°. It is shown that the edges of these are effectively parallel to the directions ⟨431⟩. These may possibly arise through intersection of {221} with the (111) face. A.

548.5

9231. Observations of spiral growth steps in ethylene polymer. R. JACCODINE. Letter in *Nature* [*London*] **176**, 305–6 (*Aug.* 13, 1955).

Preliminary work is reported of the observation of a dislocation mechanism in "Marlex 20" a predominantly polymethylene structure with limited branching along the polymer chain. The crystals were grown from hot solution in xylene, shadow cast and examined in the electron microscope. S. WEINTROUB

548.5

9232. Zone melting of decomposing solids. J. VAN DEN BOOMGAARD, F. A. KRÖGER AND H. J. VINK. *J. Electronics*, **1**, *No.* 2, 212–17 (*Sept.*, 1955).

A method is devised which makes it possible to apply the technique of zone melting to systems which would otherwise decompose. A.

ATOMIC AND X-RAY CRYSTALLOGRAPHY
548.7

548.7

9233. Revised Houston method for counting lattice frequencies. J.-L. HWANG. *Phys. Rev.*, **99**, *No.* 4, 1098–100 (*Aug.* 15, 1955).

A modified Houston–Nakamura approximation is suggested for counting lattice frequencies. This method is tested on a transversely vibrating two-dimensional lattice and found to give excellent agreement with the exact Bowers–Rosenstock solution. Following Houston, the method interpolates between symmetry lines or planes to obtain frequency contours within the Brillouin zone. The difference is that the interpolation does not follow the spherical harmonic approximation of Houston but suggests contours of specified form intermediate between circles and straight lines in two dimensions and between spheres and planes in three dimensions. Nakamura's procedure of using separate approximations in different regions of the Brillouin zone is also followed. A.

548 7

9234. Electronic states in a perturbed periodic lattice. P. FEUER. *Phys. Rev.*, **99**, *No.* 4, 1092–7 (*Aug.* 15, 1955).

Solutions of the one-dimensional Schrödinger equation for a periodic potential modified by a perturbing potential are expressed as $\psi(x) = \Sigma_k \phi(x_k)\, a(x-x_k)$. The function $a(x-x_k)$ is a Wannier function localized around the kth atom of the crystal and associated with a particular permitted band; the coefficients ϕ satisfy a differential equation of infinite order. W.B.K. solutions of the equation for ϕ are obtained. In the permitted band, ϕ is oscillatory; in the neighbouring forbidden bands ϕ decreases exponentially with distance from a band edge. Various types of perturbing potentials are considered and quantum conditions are derived for impurity states and for states in which the permitted band is crossed. A.

548.7

9235. Annealing process in neutron-irradiated LiF. D. BINDER AND W. J. STURM. Letter in *Phys. Rev.*, **99**, *No.* 2, 603–4 (*July* 15, 1955).

Following previous studies of annealing of neutron damage in LiF [Abstr. 2304 (1955)] a quantitative derivation of the annealing kinetics is made giving order of reaction, activation energy and jump frequency for lattice defects. Experimental results indicate a second-order reaction due to random recombination of isolated vacancies and intensities.

G. F. J. GARLICK

548.7

9236. Impurity diffusion in polar crystals. A. B. LIDIARD. *Phil. Mag.*, **46**, 815–23 (*Aug.*, 1955).

A theoretical discussion of the diffusion of divalent impurities in polar crystals of the NaCl type is given with the aid of the Stasiw–Teltow association model. It is shown how accurate measurements of the impurity diffusion coefficient can yield fundamental

information about the existence and concentration of impurity–vacancy pairs ("complexes") in a simple and direct manner. Such measurements would therefore provide a valuable addition to the studies of ionic crystals already made of their ionic conductivity, dielectric loss, etc. The main restriction of the present theory is that the impurity–vacancy complexes should have a mean lifetime which is long compared with the mean jump times which govern their changes of position and orientation. A.

548.7

9237. Calculation of the entropies of lattice defects. H. B. HUNTINGTON, G. A. SHIRN AND E. S. WAJDA. *Phys. Rev.*, **99**, *No.* 4, 1085–91 (*Aug.* 15, 1955).

The entropy of lattice defects are here considered in somewhat greater detail than previously. Calculations are out to estimate the intrinsic entropies associated with such lattice defects as interstitialcies and vacancies, and with the activated complexes of vacancy and ring diffusion. The present application is to *fcc* metals and a very simplified force model representing only the closed-shell, ion-core repulsions of copper has been used. The problem consists in evaluating the change of lattice vibrations with the introduction of each defect. The method is in a first approximation to consider vibrations localized around the defect as separate from elastic vibrations at appreciable distance from the defect. Only in the region far from the defect is the entropy contribution always positive. The surface condition of zero pressure introduces a term which reduces the effect of the "localized" vibrations. In general the intrinsic entropy is less positive for those configurations where there is crowding of the atoms than for those configurations where the atoms have greater free volume. A.

548.7

9238. Dislocations in germanium. S. G. ELLIS. *J. appl. Phys.*, **26**, *No.* 9, 1140–9 (*Sept.*, 1955).

A light microscope study of etched germanium crystals has shown the dislocation distribution in them. The dislocations form a network in the crystal. The formation of small angle grain boundaries is discussed. Screw dislocations with large Burgers vectors have been found in some germanium crystals. A.

548.7

9239. Continuous distributions of dislocations: a new application of the methods of non-Riemannian geometry. B. A. BILBY, R. BULLOUGH AND E. SMITH. *Proc. Roy. Soc. A*, **231**, 263–73 (*Aug.* 22, 1955).

When describing a crystal containing an arbitrary distribution of dislocation lines it is often convenient to treat the distribution as continuous, and to specify the state of dislocation as a function of position. Formally, however, there is then no "good crystal" anywhere, and difficulties arise in defining Burgers circuits and the dislocation tensor. The dislocated state may be defined precisely by relating the local basis at each point to that of a reference lattice. The dislocation density may then be defined; it is important to distinguish this from the local dislocation density. The geometry of the continuously dislocated crystal is most conveniently analysed by treating the manifold of lattice points in the final state as a non-Riemannian one with a single asymmetric connection. The coefficients of connection may be expressed in terms of the generating deformations relating the dislocated crystal to the reference lattice. The tensor defining the local dislocation density is then the *torsion tensor* associated with the asymmetric connection. Some properties of the connection are briefly discussed and it is shown that it possesses that of distant parallelism, in conformity with the requirement that the dislocated lattice be everywhere unique. A.

548.7 : 535.371

Current problems in crystalline luminescence. *See Abstr.* 8637

548.7

9240. Further observations on color center precursors. M. HACSKAYLO AND P. SCHWED. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1362–3 (*July*, 1955).

NaCl crystals are sensitized by electrolysis for coloration by X-rays [see Abstr. 8562 (1952), 3727 (1953), 872 (1954)]. Additively coloured NaCl bleached by electrolysis also sensitizes the crystals. Detailed absorption spectra are studied for these sensitized crystals. G. F. J. GARLICK

548.7 : 535.376

9241. Production of a blue color in irradiated plastic scintillators. J. H. PANNELL AND B. MANNING. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1368–9 (*July*, 1955).

Beta-irradiation of polystyrene or polyvinyltoluene containing fluorescent molecules (terphenyl, etc.) produces a blue coloration which can be bleached by visible light. At −70°C colour production is more rapid and after irradiation warming produces thermoluminescence which peaks at 450 mμ and is similar in spectrum to that of emission under β-excitation. At 1 Mc/s the permittivity increases on coloration but decays to normal as the colour bleaches out. The coloration is independent of the included compounds in the plastic. G. F. J. GARLICK

548.7 : 666

9242. *F*-centres in metaphosphate glass. S. BASU. Letter in *Nature* [*London*] **176**, 265–6 (*Aug.* 6, 1955).

Glasses are produced by heating sodium dihydrogen phosphate with suitable additions at 900°C in a platinum tray. X-ray irradiation produces absorption bands at 510, 490 and 340 mμ. Visible absorption increases with sodium content. It is suggested that the visible bands arise from trapped electrons and the u.v. band from trapped positive holes. Band positions are in remarkable agreement with those for borate and silicate glasses. G. F. J. GARLICK

548.7

9243. *F′* and *K* centers in additively colored KCl crystals. F. E. GEIGER, JR. *Phys. Rev.*, **99**, *No.* 4, 1075–8 (*Aug.* 15, 1955).

Measurements are reported on the *F*–*F′* process, and the *K*-band in additively coloured KCl. The crystals are coloured with distilled potassium, and subjected to repeated cycles of optical bleach with *F* light (5450 Å) at 170°K and thermal bleach of the *F′*-centres at room temperature. It is found that the optical quantum efficiency of conversion of *F*- to *F′*-centres varies in two ways: (*a*) The quantum efficiency varies significantly for different specimens

of coloured KCl all cleaved from the same one-inch cube of KCl. (*b*) The optical quantum efficiency drops significantly after each cycle of *F*-centre bleach and subsequent thermal bleach of the *F'*-centres. Ultimately, the quantum efficiency appears to decrease to a point where the crystal is essentially unaffected by *F* light at 170°K. *K*-centres are influenced to a lesser degree, if at all, than *F*-centres by optical bleaching in the *F*-band at 170°K. All absorption measurements are made in the visible part of the spectrum. A.

548.7

9244. The structure of the colour centres in smoky quartz. M. C. M. O'Brien. *Proc. Roy. Soc. A*, **231**, 404–14 (*Sept.* 6, 1955).

A model is proposed to account for the properties of the colour centres produced by irradiation by X-rays in quartz. The hyperfine structure of the paramagnetic resonance spectrum shows that each centre is associated with an aluminium atom, and the model puts the aluminium atom at a silicon site in the lattice with the unpaired electron in a localized orbital on one of the nearest oxygen atoms. The axes of the "*g*" tensor and the variation of *g* with direction are predicted unambiguously, as is the axis of the quadrupole interaction. The magnitude and axes of the magnetic hyperfine structure are not predicted, but they are explained in terms of the model. The energy levels deduced theoretically using the paramagnetic resonance data are used to give a tentative interpretation of the optical absorption spectrum. Finally an account is given of the effects to be expected if there is an interaction between the two different colour centres that can be associated with a particular aluminium atom. A.

548.7 : 539.132

9245. Spin-echoes in the presence of non-axially symmetric quadrupole interaction in crystals. T. P. Das and D. K. Roy. *Proc. Roy. Soc. A*, **231**, 244–50 (*Aug.* 22, 1955).

Spin-echo amplitudes for spins $I = 1$, $\frac{3}{2}$ and $\frac{5}{2}$ have been worked out in the presence of weak electric quadrupole interaction in crystals with non-axial electric field gradients. The effects of first- and second-order perturbation due to the quadrupole interaction in causing a modulation of the spin-echo signals have been analysed in detail in comparison with the splitting and shift effects they cause in the steady experiment. A.

548.7 : 535.55

9246. Photoelastic observations of the expansion of alkali halides on irradiation. W. Primak, C. J. Delbecq and P. H. Yuster. *Phys. Rev.*, **98**, *No.* 6, 1708–15 (*June* 15, 1955).

Alkali halide crystals subjected to a non-uniform irradiation by X-rays or high-energy deuterons are found to become anomalously birefringent. The effect has been studied in detail in lithium fluoride. It is shown that the birefringence is due to the photoelastic effect accompanying a non-uniform dilatation which is calculated from the measured birefringence with the aid of elasticity theory. The crystals are coloured as a result of the irradiation; and from the absorption coefficients, the number of colour centres per unit volume is calculated. It is found that the volume of vacancies per unit volume is approximately equal to the dilatation. A possible explanation for this result is that the vacancies associated with the colour centres are generated at the jogs of edge dislocations during irradiation. A.

548.7

9247. Time-dependent displacement correlations and inelastic scattering by crystals. R. J. Glauber. *Phys. Rev.*, **98**, *No.* 6, 1692–8 (*June* 15, 1955).

A function is defined which expresses quantum mechanically the correlation of the displacements of pairs of lattice points at different times due to the wave-like nature of crystal excitations. Methods are developed for summing implicitly the effects of multiple emission and absorption of lattice quanta occurring during a scattering process. The inelastic scattering cross-sections found thereby are expressed entirely in terms of the time-dependent correlation function defined earlier. The resulting treatment thus emerges as a natural generalization of the static theory X-ray scattering. The results are discussed in relation to a number of approximation methods. A.

548.7 : 538.24

9248. Domain patterns on rolled single crystal of Ni_3Fe. S. Chikazumi and K. Suzuki. Letter in *Phys. Rev.*, **98**, *No.* 4, 1130 (*May* 15, 1955).

These show that the magnetization is always along $[1\bar{1}0]$ direction. The rolling plane is always (110). The observed changes in the anisotropy of magnetization may be explained by assuming that slip on the (111) and $(11\bar{1})$ planes destroys the order in all directions except $[1\bar{1}0]$, leaving a uni-directionally ordered structure. W. M. Lomer

548.7

9249. Domain configurations and crystallographic orientation in grain-oriented silicon steel. W. S. Paxton and T. G. Nilan. *J. appl. Phys.*, **26**, *No.* 8, 994–1001 (*Aug.*, 1955).

The magnetic domain structure of polycrystalline grain-oriented $3\frac{1}{4}\%$ silicon steel has been investigated by the magnetic-powder-pattern technique and the orientation of individual grains determined by the etch-pit optical-goniometer technique. A semi-quantitative relationship has been found between the domain patterns and crystalline orientation. The observed powder patterns can be grouped into five types, depending upon the angle, ϕ, between the rolling plane and the $\langle 100 \rangle$ direction lying closest to the rolling plane. When the rolling direction is known and ϕ is $<10°$, semiquantitative grain-by-grain orientation information can be obtained solely from the domain patterns. The behaviour of two of the types of patterns in an applied magnetic field is shown, and on the basis of this behaviour, a three-dimensional domain configuration is proposed for one of the less complicated surface patterns. A.

548.7

9250. A study of domain structures in alnico. L. F. Bates and D. H. Martin. *Proc. Phys. Soc. B*, **68**, *Pt* 8, 537–40 (*Aug.*, 1955).

The Bitter figure technique is used to study domain structures on polycrystalline alnico specimens with coercivities ranging from 0 to 100 oersteds, in which recognizable domains are recorded. In low coercivity

specimens the domains are bounded by comparatively straight walls but they show more irregular outlines in high coercivity specimens. A.

548.7

9251. Edge energies of alkali halide crystals. H. P. Schreiber and G. C. Benson. *Canad. J. Phys.*, **33**, *No.* 9, 534–40 (*Sept.*, 1955).

Theoretical calculations of the energies of ⟨100⟩ edges of sodium and potassium halide crystals are described. The present computations differ from those of previous workers by the inclusion of terms arising from van der Waals forces. It appears that these forces make a significant contribution to the edge energy. A.

548.73/.74

9252. Correlation of diffraction and transmission experiments for X-ray and neutron elastic scattering. D. T. Keating and J. J. Antal. *J. appl. Phys.*, **26**, *No.* 8, 1041–4 (*Aug.*, 1955).

The correlation of a neutron cross-section plot in the cutoff region and a diffraction pattern has been considered. The cross-section for elastic scattering by a sample as determined from transmission experiments has been related to its diffraction pattern. A cross-section plot can be transformed into a diffraction pattern by combining the cross-section and its derivative. Examples of neutron cutoffs exhibiting strain and particle-size broadening (carbonyl iron) and exhibiting particle-size broadening alone (MgO) have been transformed. The patterns derived by the relation show good agreement with the X-ray diffraction patterns. Cross-section plots are sensitive to the state of crystalline perfection of the sample to the same degree as are diffraction patterns. Comparisons between the two should be made by performing the transformations given in the paper. A.

548.73/.74

X-ray and electron investigation of materials. *See also under* "Structure of solids." Decimal classification 539.26/.27

548.732 : 539.4.016.2

9253. X-ray extinction and the effect of cold work on integrated intensities. G. K. Williamson and R. E. Smallman. *Proc. Phys. Soc. B*, **68**, *Pt* 9, 577–85 (*Sept.*, 1955).

Previous results on the intrinsic effect of cold work on integrated intensities are interpreted using the latest extinction corrections and a new method of plotting which gives reasonable differentiation between the various possible corrections. It is shown that cold work reduces the integrated intensities of the line by a small factor of between 3 and 5% and this intensity goes into the background as overlapping long tails to the lines. A.

548.733

9254. A simple device for obtaining X-ray diffraction patterns from coarse-grained materials. R. W. Cahn and T. W. Baker. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. M/M*35, 2 *pp.* (1951).

A simple device is described for use in conjunction with a "Unicam" X-ray goniometer, which will give good Debye–Scherrer lines with coarse-grained or single crystalline material. A.

548.733

9255. X-ray diffractometer for highly radioactive materials. M. A. Bredig, G. E. Klein and B. S. Borie, Jr. Letter in *Rev. sci. Instrum.*, **26**, *No.* 6, 610 (*June*, 1955).

Describes a method involving the use of a proportional counter or scintillation counter (with or without a bent-crystal monochromator, which is placed between the specimen and the detector). The sample may be placed and scanned by remote control, and the counter assembly is protected by lead shielding. Even without the monochromator radioactive material giving 12 r/hr at 1 cm can be examined. The limit when the monochromator is used is not stated. J. THEWLIS

548.733

9256. The design and operation of an X-ray diffraction apparatus with a Geiger counter. Y. Yoneda, K. Kohra and T. Futagami. *Mem. Fac. Engng Kyushu Univ.*, **15**, *No.* 1, 165–79 (1955).

548.733

9257. Point focusing of an X-ray beam. A.-J. Rose and J. Barraud. *Bull. Soc. Franç. Minéral. Crist.*, **78**, *No.* 7–9, 449–60 (*July–Sept.*, 1955) In French.

A point focus (area $\sim 0{\cdot}001\ mm^2$) is obtained by means of two curved crystals with their generator axes mutually perpendicular. The calculation of the radii of curvature and positions of the crystals is described. Examples are given of powder photographs obtained by the use of the focused beam.

A. R. STOKES

548.733

9258. A simple version of Bragg's X-ray microscope. B. D. Dunkerley and H. Lipson. Letter in *Nature* [*London*] **176**, 81–2 (*July* 9, 1955).

The mask representing the diffraction amplitudes of the crystal is photographically reduced, so that its diffraction pattern may be observed with an ordinary telescope, using a "point" source but no collimator. A specimen diffraction pattern is reproduced.

A. R. STOKES

548.734

9259. A device for studying the Compton effect in crystals. H. Curien. Letter in *J. Phys. Radium*, **16**, *No.* 6, 494–5 (*June*, 1955) In French.

Compton scattering may be separated from thermal diffuse scattering by the use of an appropriate filter; a Mo filter could be used for Rh $K\alpha_2$ radiation, or a Ni filter could be used for W $L\alpha_2$ radiation.

A. R. STOKES

548.734

9260. Orientation of single-crystal fragments by means of X-ray rotation photographs. R. B. Roof, Jr. *Acta Cryst.*, **8**, *Pt* 7, 434–9 (*July*, 1955).

The general problem of orientation of a single-crystal fragment for rotation about a unit-cell edge is considered. The method consists of utilizing three rotation photographs to determine the position of two reciprocal-lattice points relative to the plane of the lower arc of the goniometer and the corrections necessary to move the arcs to bring the crystal into orientation. A.

548.734

9261. Precession goniometry to identify neighboring twins. G. DONNAY, J. D. H. DONNAY AND V. J. HURST. *Acta Cryst.*, **8**, *Pt* 8, 507–9 (*Aug.*, 1955).

The two limiting circles which appear on a properly chosen orientation picture, taken with the precession camera, are used to identify the twin law in the case of neighbouring twins. A.

548.734 : 536.48

9262. A method of examining structural changes of metals on deformation in liquid helium: examination of indium. W. B. PEARSON. *Canad. J. Phys.*, **33**, *No.* 8, 473–5 (*Aug.*, 1955).

A Debye–Scherrer type of X-ray camera is described in which a soft metal can be deformed by extension and photographed *in situ* in liquid helium. Using this camera deformed indium has been examined at 4·2°K and no evidence found of a lattice transformation when a tensile strain of ~15% is applied. The investigation was undertaken to examine the suggestion of Swensen, stemming from the observation of anomalies in the mechanical properties of indium at low temperatures, that a very slight deformation of indium at 4·2°K might transform the face-centred tetragonal to a close-packed structure. A.

548.735

9263. The probability distribution of intensities. VI. The influence of intensity errors on the statistical tests. D. ROGERS, E. STANLEY AND A. J. C. WILSON. *Acta Cryst.*, **8**, *Pt* 7, 383–93 (*July*, 1955).

For Pt V, see Abstr. 8079 (1953). The statistical tests, three for centrosymmetry and one for planes of symmetry, have been examined to determine quantitatively their sensitivity to errors in the original intensity data. The errors considered are (i) random errors proportional to I, (ii) errors systematic in I of the form $I_0 = k\Sigma[1-\exp(-I/k\Sigma)]$, (iii) errors systematic in $\sin\theta$, and (iv) errors associated with the non-observance of very weak reflections. Errors (i) and (ii) of ordinary magnitude produce no confusion. Errors (iii) can affect the tests only through errors in the determination of $\langle I\rangle$ as a function of $\sin^2\theta$, and to these the tests are rather sensitive. Errors (iv) can also have marked effects, for which, however, allowances can be made. The tests are unequally affected by a given amount of error, but the results derived here permit the estimation in a given problem of likely outer limits for the result of each test. Results lying outside this limit may be regarded as significantly different and indicative of some structural peculiarity. A.

548.735

9264. Vector distributions and crystalline proteins. D. WRINCH. Letter in *J. chem. Phys.*, **23**, *No.* 7, 1361 (*July*, 1955).

It is shown that a cage-like structure can give a vector map with peaks outside the central peak; such peaks do not necessarily indicate the existence of separate regions of high density. The bearing of this on protein structure is briefly discussed. A. R. STOKES

548.735

9265. An analysis of the efficiency of convergence of different methods of structure determination. II. The method of Fourier synthesis: centrosymmetric case. M. M. QURASHI. *Acta Cryst.*, **8**, *Pt* 8, 445–56 (*Aug.*, 1955).

For Pt I, see Abstr. 8084 (1953). A discussion of the rate and "efficiency" of convergence of the method of Fourier synthesis is presented for the case of large departures of the assumed approximation from the correct structure. The Fourier synthesis is first reduced to its exactly equivalent minimum-residual solution, with inclusion of the effect of incorrect signs of the structure factors. A mathematical expression is then obtained for the efficiency of convergence, $\eta_{F.S.}$ (=calculated correction/actual correction required), for an n-dimensional summation. $\eta_{F.S.}$ is finally expressed as a function of $U = 2\pi\Delta/d_{\min.}$, where Δ is the r.m.s. error per atomic co-ordinate. (In the process, graphs are obtained for the integral reliability index, $R_I = \Sigma W^2||F_o|-|F_c|| \div \Sigma W^2|F_c|$, as a function of U for both weighted and unweighted Fourier syntheses; these graphs are practically identical for 1-, 2- and 3-dimensional summations, and should be useful for estimating Δ directly from R_I.) The behaviour of $\eta_{F.S.}$ under various conditions is discussed, and is found to be similar to $\eta_{S.D.}$ for the methods of steepest descents and least squares. Curves are given for $\eta_{F.S.}$ against U, against $U_c = \eta_{F.S.} \times U$, and against R_I, all of which are useful under different conditions for (*a*) estimating $\eta_{F.S.}$ and (*b*) speeding up the convergence by dividing the calculated corrections by $\eta_{F.S.}$. The influence of neighbouring atoms and of statistical fluctuations on the reliability of the calculated value of $\eta_{F.S.}$ is discussed analytically. A.

548.735

9266. Calculation of geometrical structure factors for space groups of low symmetry. II. E. W. RADOSLOVICH. *Acta Cryst.*, **8**, *Pt* 8, 456–60 (*Aug.*, 1955).

An instrument (called SUMCOS) described in Pt I [Abstr. 4192 (1955)] assists in the calculation of $\Sigma_j \cos(hx_j + ky_j + lz_j)$ by hand. It does this by forming $\cos(hx_j + ky_j + lz_j)$ separately for ten atoms, and simultaneously presenting the values of these ten cosines ready for addition for any given (h, k, l). The final addition must be done by hand. The values of $\cos(hx_j + ky_j + lz_j)$ are derived from a table of $\cos hx_j$ by using a simple mechanical arrangement to shift the origin of this table by $(ky_j + lz_j)$. The values are presented for addition by switching on a small light behind the particular value of $\cos hx_j$ on the table, which is written on translucent material. New values of $\cos(hx_j + ky_j + lz_j)$ are presented for successive h simply by turning to the next position of a 24-position switch. A.

548.735

9267. Relations between the phases of structure factors. W. COCHRAN. *Acta Cryst.*, **8**, *Pt* 8, 473–8 (*Aug.*, 1955).

Relations between the phase angles of complex structure factors (analogous to the sign relations which are known to apply for real structure factors) are derived, and their possible application to crystal-structure analysis is discussed. A.

548.735

9268. New calculations of atomic scattering factors. J. Berghuis, IJ. M. Haanappel, M. Potters, B. O. Loopstra, C. H. MacGillavry and A. L. Veenendaal. *Acta Cryst.*, **8**, *Pt* 8, 478–83 (*Aug.*, 1955).

Scattering factors for twenty-three atoms have been calculated from Hartree and Hartree–Fock radial wave-functions. The results are compared with James and Brindley's values and with those recently obtained by other authors. A.

548.735

9269. A generalized treatment of cold work in powder patterns. B. E. Warren. *Acta Cryst.*, **8**, *Pt* 8, 483–6 (*Aug.*, 1955).

Calculations of the effect of particle-size and cold-work distortion in the broadening of powder-pattern lines have been simplified in several previous treatments by considering the reflections as 00*l* for orthorhombic axes. By a suitable transformation of variables and axes, it is possible to carry through the calculation for the general *hkl* reflection for a crystal of any system. The general result obtained is identical to that previously obtained with the simplifying assumptions. The result is expressed in terms of particle-size and distortion Fourier coefficients which are obtained from the experimental peak shapes. A.

548.735

9270. The effect of atoms in fixed positions on the statistical tests for symmetry centers. R. L. Collin. *Acta Cryst.*, **8**, *Pt* 8, 499–502 (*Aug.*, 1955).

The probability distribution of X-ray intensities is altered by the presence of atoms in fixed positions. If these atoms are heavy enough, they will in turn affect the statistical tests that are used to distinguish centric from acentric structures. However, if the positions of these fixed atoms are known, distribution curves can be calculated for both centric and acentric structures. A comparison of these curves with the observed intensity distribution will allow one to infer the presence or absence of a symmetry centre. A.

548.735.7 : 539.4.016.2

9271. Interpretation of the strain broadening components in X-ray diffraction patterns. J. C. Bowman, J. A. Krumhansl and J. R. Stock. Letter in *J. appl. Phys.*, **26**, *No.* 8, 1057–8 (*Aug.*, 1955).

See Abstr. 6755 (1950), 6187 (1952). It is shown that the results of line-breadth measurements on cold-worked brass, and the derived lattice strains, can be explained in terms of statistical theory of lattice strains, which shows that the mean square displacement ΔL^2 between planes distance L apart is proportional to L. This theory assumes that the displacement between successive planes are statistically independent. A. R. STOKES

548.736.3

9272. X-ray diffraction patterns of $TiCl_2$ and $TiCl_3$. M. Farber, A. J. Darnell and F. Brown. Letter in *J. chem. Phys.*, **23**, *No.* 8, 1556 (*Aug.*, 1955).

Gives methods of preparation, and *d*-values and relative intensities of powder diffraction lines.

A. R. STOKES

548.736.3 : 539.185

9273. X-ray scattering by neutron-irradiated single crystals of boron carbide. I. C. W. Tucker, Jr and P. Senio. *Acta Cryst.*, **8**, *Pt* 7, 371–8 (*July*, 1955).

Neutron irradiation of single crystals of boron carbide produces very strong X-ray diffraction effects. These effects are (*a*) contraction of the lattice in the c_0 direction and expansion in the a_0 direction, (*b*) an anisotropic artificial temperature factor which is six times as strong in the c_0 direction as in the a_0 direction, (*c*) changes in the average lattice positions of a number of the atoms, and (*d*) very heavy diffuse scattering surrounding many of the reciprocal-lattice points. Annealing experiments show that most of the X-ray effects are removed in the temperature range of 700 to 900°c. The present work shows that the effects are due to the production of the anisotropic defect in the lattice. This defect is produced by the selective removal of the central carbon atom in a chain of three carbon atoms which lies parallel to the c_0 axis. In the 700–900°c range the selectively removed carbon atom becomes mobile and finds its way back to its normal position. The effects are interpreted qualitatively in terms of an elastic model of Huang. Work is in progress to extend the analysis of Huang to the case of anisotropic defects and to measure and interpret the diffuse scattering in detail. A.

548.736.4

9274. On the structures of some compounds of the perovskite type. H. L. Yakel, Jr. *Acta Cryst.*, **8**, *Pt* 7, 394–8 (*July*, 1955).

X-ray powder diffraction patterns of a number of compounds and solid solutions of the type ABO_3, where B is a transition metal element, have been recorded and interpreted. These substances all have perovskite-like structures, with characteristic lattice distortions and multiple unit cells which are a result of partial covalent bonding. Variations of structures with differing conditions of preparation are noted for $LaMnO_3$ and $CaMnO_3$, where the results of chemical analyses show that these variations accompany departures from stoichiometric composition. Solid solutions of $LaMnO_3$ and $CaMnO_3$ obey Vegard's rule, a decrease in unit cell volume being produced by the substitution of Ca^{+2} and Mn^{+4} ions in the $LaMnO_3$ structure. An unusual increase in unit cell volume is, however, observed when Sr^{+2} and Co^{+4} ions are substituted in the $LaCoO_3$ structure. A.

548.736.4 : 538.221

9275. A review of the structure and some magnetic properties of ferrites. L. C. F. Blackman. *J. Electronics*, **1**, *No.* 1, 64–77 (*July*, 1955).

The combination of high electrical resistivity and useful magnetic properties has caused ferrites to become increasingly important as high-frequency core materials. A description of the general structural and saturation magnetization properties of the more simple ferrites, and of their preparation, is followed by a brief account of the current theories of the magnetic interaction associated with ferromagnetism. A.

548.736.4 : 538.221

9276. Ferromagnetic titanomagnetites and ilmenites. I. Optical, radiocrystallographic and chemical study. II. Study of magnetic properties. R. Chevallier, J. Bolfa and S. Mathieu. *Bull. Soc. Franc. Minéral. Crist.*, **78**, *No.* 4–6, 307–46 (*April–June*); *No.* 7–9, 365–99 (*July–Sept.*, 1955) In French.

548.736.5

9277. The crystal structure of lanthanum–strontium manganites. M. G. HARWOOD. *Proc. Phys. Soc. B*, **68**, *Pt* 9, 586–92 (*Sept.*, 1955).

The lanthanum manganite–strontium manganite system has been examined as a function of the lanthanum content. The perovskite phase is stable from 23 to 100% lanthanum. At the lower limit of stability it is of cubic symmetry, the unit cell becoming rhombohedral between 50 and 60% lanthanum. In the lanthanum manganese oxygen system of general formula $LaMnO_x$ the value of x has been varied between 3·24 and 3·07. Over the entire range the structure is of the perovskite type with small type of cell. At the oxygen-rich end of the system the symmetry is rhombohedral while at the other end it is cubic. In both systems the relations between the lattice parameters and composition and magnetic Curie temperatures are indicated. A.

548.74

9278. Interference-refraction of electron beams. III. Determination of the crystal orientation, the structure factors and the inner potential of magnesium oxide crystals from the fine structure of the electron diffraction spots. K. MOLIÈRE AND H. NIEHRS. *Z. Phys.*, **140**, *No.* 6, 581–607 (1955) In German.

For Pt II, see Abstr. 641 (1955). The method, in which a submicroscopic cube-shaped crystal is used, is described and applied to MgO, for which the structure potentials (Fourier coefficients of the potential) are in good agreement with theory. The inner potential appears to be independent of the indices of the reflection, the electron velocity or the beam intensity but the value obtained is several volts higher than the theoretical one. J. THEWLIS

548.74

9279. Long-wavelength neutron transmission as an absolute method for determining the concentration of lattice defects in crystals. J. J. ANTAL, R. J. WEISS AND G. J. DIENES. *Phys. Rev.*, **99**, *No.* 4, 1081–5 (*Aug.* 15, 1955).

The scattering of long-wavelength neutrons by lattice defects has been used to measure in an absolute way the number of isolated interstitial atoms and vacancies introduced in graphite by reactor irradiation. For an exposure of $1{\cdot}1\times10^{20}$ neutrons/cm^2 the fraction of displaced atoms was found to be 0·0263. This value is more accurate than present theoretical estimates largely because of uncertainties in exposures. Within this limitation the experimental value is in excellent agreement with that derived from Seitz's theory. A.

548.74 : 539.185

9280. Thermal inelastic scattering of cold neutrons in polycrystalline solids. L. S. KOTHARI AND K. S. SINGWI. *Proc. Roy. Soc. A*, **231**, 293–307 (*Sept.* 6, 1955).

A general theory of the influence of thermal motion on the scattering of slow neutrons in polycrystals is discussed. Unlike Weinstock's earlier treatment of the same problem, the temperature displacements of the lattice points are here treated as a sum of emission and absorption operators. This alternative approach simplifies the calculation of the transition probability to a considerable extent and provides a simple proof of the Debye–Waller factor. The theory is also generalized to the case of multi-phonon processes. General expressions for both the incoherent and coherent cross-sections, corresponding to an "l" phonon process, are derived. The latter, hitherto not treated rigorously, is examined in detail. It is shown that it can be expressed as a sum of two terms, of which the main term, apart from a constant, is identical with the expression for the incoherent part and the other is a correction term. Both terms are put in "Placzek" form, and for cold neutrons explicit expressions are obtained for the cases: (i) $M \gg 1$ and $T/\Theta \geqslant 1$, and (ii) $M \sim 10$ and $T/\Theta \geqslant 0{\cdot}5$. Numerical results for magnesium, aluminium, iron, lead and beryllium are discussed and compared with experiment. The agreement is found to be satisfactory. A.

GEOPHYSICS 55

550.3 : 550.8

9281. The phenomenon of fluctuations in geophysics. Their mathematical description and their practical application. M. MATSCHINSKI. *R.C. Accad. Naz. Lincei*, **18**, *No.* 4, 378–85 (*April*, 1955) In Italian.

The description of fluctuation by ellipses, or ellipsoids, instead of circles, or spheres, is developed using the principle of transposition. [See *C.R. Acad. Sci.* [*Paris*] **239**, *No.* 22, 1457 (*Nov.* 29, 1954).] It is shown that the fluctuations of a field potential, determined by the tensor-means, are a double gradient of a scalar super potential Φ, which resolves the equation $\Delta\Phi = 0$. This superpotential is the potential of the fluctuations. This fact is held to be very useful for problems concerning gravitic and electromagnetic fields, mineral prospecting, etc., and permits use of measurements of the fluctuations of the primary derivatives (of one point) rather than those of the secondary derivatives (of two adjacent points). J. J. PHIPPS

550.372

9282. Geoelectric consolidation of soil by means of effective simultaneous mechanical pressure. V. FRITSCH. *Geofis. pura appl.*, **30**, *No.* 1, 86–92 (1955) In German.

Experiments were made with intermittent and continuous mechanical methods of consolidation. They show that the methods of consolidation must be correctly chosen with regard to both their quantitative and temporal succession if they are to support each other. The experiments show further that close by the anode, through the so-called effect of coherence, the conductivity of the soil is essentially higher. The problem is by no means completely cleared. A.

550.372

9283. The pressure effect on the electrical conductivity of peridot. H. HUGHES. *J. geophys. Res.*, **60**, *No.* 2, 187–91 (*June*, 1955).

The effect of pressure on the ionic conductivity of peridot is measured and its influence on the electrical conductivity and temperature of the earth's mantle discussed. A.

550.372 : 621.3.011.22

9284. A study of a.c. resistivity of Calcutta soil. S. P. BHATTACHARYYA. *Indian J. Phys.*, **29**, *No.* 3, 141–6 (*March*, 1955).

Deals with resistivity variations with temperature and moisture content of the soil. A.

550.372 : 621.3.011.5

9285. The influence of temperature and humidity on the electric constants of the soil. M. ARGIROVIĆ. *Ann. Télécomm.*, **10**, *No.* 5, 113–16 (*May*, 1955) In French.

The conductivity of soil is almost entirely ionic. On the assumption that the conductivity and permittivity of the soil vary with temperature following exponential laws, expressions are derived for the variation in amplitude of a radio ground wave with temperature. There is good agreement between two sets of measured and calculated field strengths for a temperature range of 0 to 20°C. The effects of humidity and its dependence upon temperature and other weather conditions are discussed.

W. T. BLACKBAND (R)

ATMOSPHERE . METEOROLOGY 551.5

551.510.535

9286. Thunderstorms and sporadic *E* ionization of the ionosphere. S. K. MITRA AND M. R. KUNDU. Letter in *Nature* [*London*] **174**, 798–9 (*Oct.* 23, 1954).

During the incidence of "nor' wester" type of severe thunderstorms in the pre-monsoon months at Calcutta it is found that *fEs* invariably increases, reaching a peak value (as high as 10 Mc/s compared with an average no-storm value of 3·5–5 Mc/s) soon after the time of highest gust (squall overhead). The results suggest that at least one of the causes of *Es* ionization is associated with thunderstorms.

G. M. BROWN

551.510.535

9287. The mechanism of the generation of inhomogeneities in the ionosphere. B. N. GERSHMAN AND V. L. GINZBURG. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 4, 647–50 (1955) In Russian.

It is argued that these inhomogeneities cannot be due to meteorites, interstellar gas, or winds in the ionosphere, and a new mechanism is suggested, related to the generation of convective instability in the ionosphere; a similar instability causes granulation in the sun. The convection is due to the fall in temperature with increasing height above 300–400 km, and leads to the formation of cellular convection structure. It is shown that the temperature gradient, viscosity and temperature conductivity provide (particularly at night) suitable conditions for the generation of convection. The calculated cell dimension (~40 km) does not differ very much from the observed values (~5 km). The effect of the Coriolis acceleration and of the earth's magnetic field is discussed. F. LACHMAN

551.510.535

9288. Notes on correlation methods for evaluating ionospheric winds from radio fading records. D. G. YERG. *J. geophys. Res.*, **60**, *No.* 2, 173–85 (*June*, 1955).

A correlation method requiring six values of the correlation coefficient is developed. Expressions for the drift velocity, fading velocity and characteristic velocity are obtained from a correlation theory extended to include an elliptical contour in the horizontal plane. The physical significance of the derived velocities is considered. Preliminary data indicate that the correlation ellipse exhibits a preferred orientation and that fading associated with random changes is as important as fading associated with a drifting pattern. A.

551.510.535

9289. The effects of anisometric amplitude patterns in the measurement of ionospheric drifts. G. J. PHILLIPS AND M. SPENCER. *Proc. Phys. Soc. B*, **68**, *Pt* 8, 481–92 (*Aug.*, 1955).

In certain observations of a downcoming radio wave, made for the purpose of measuring horizontal drifts of ionospheric irregularities, time shifts between fading curves obtained at three spaced receiving points are used to calculate the velocity and direction of drift of the amplitude pattern over the ground. Two simplifying assumptions about the pattern are frequently made, namely (i) the detail remains constant as it moves, and (ii) it is statistically isometric, i.e. the separation of two points for which the amplitudes have a given fixed correlation is independent of direction. The errors that arise if assumption (i) is wrong have been considered previously. But a more general analysis, not relying on either assumption may be applied to the three fading curves, and the result expressed (either analytically or graphically) as the error of a calculation which makes the two assumptions. One important result is that if assumption (iii) is not valid the error in direction of drift may be quite serious. Thus, in an application to amplitude patterns produced by vertical reflection at 2·4 Mc/s (principally from the *E*-layer), errors in individual results averaged 15°. Because the structure of the pattern varied from sample to sample, the error was not, in this case, systematic. But, in some applications, a preferred direction of the pattern structure could, if ignored, lead to wrong conclusions about preferred directions of drift. A.

551.510.535

9290. The shape of irregularities in the upper ionosphere. M. SPENCER. *Proc. Phys. Soc. B*, **68**, *Pt* 8, 493–503 (*Aug.*, 1955).

Observations of radio stellar scintillation on a frequency of 38 Mc/s were made with three spaced receivers. Suitable records were analysed to determine the average shape of the irregularities in the amplitude pattern on the ground. It was found on all occasions that the irregularities were elongated by

a factor of at least 5 : 1, indicating that the ionospheric irregularities responsible for the amplitude pattern were also very elongated. The directions of stretching were consistent with the hypothesis that the irregularities in the ionosphere were extended along the earth's magnetic lines of force. Further evidence is presented which confirms the hypothesis. It is pointed out that under these conditions it is not possible to determine true velocities of drift from the time shifts between fading curves obtained at spaced receivers, and that the results of previous workers may be seriously in error. The movement, and the diffusion, of irregularities of the kind here considered are briefly discussed. A.

551.510.535

Radio-wave propagation in the ionosphere. *See also under* "Electromagnetic waves and oscillations." Decimal classification 538.566.3

551.510.535 : 523.164

Radio star scintillations and the ionosphere. *See Abstr.* 8445

551.510.535 : 550.38 : 523.75

9291. Effect of radiation from solar flares on the ionosphere and the earth's magnetic field. R. N. Sedra and I. B. Hazzaa. *Phys. Rev.*, **99**, *No.* 4, 1070–2 (*Aug.* 15, 1955).

Variation in the earth's magnetic field and the corresponding variations in the ionic density of the F_1-layer due to solar flares are recorded. The value of the intensity of ultraviolet radiation before it enters the atmosphere is obtained. The constant relating the ionic density and the accompanying magnetic variation is also estimated. A.

551.574

9292. Abnormal freezing nuclei in the atmosphere. B. M. Cwilong. Letter in *Nature* [*London*] **176**, 129–30 (*July* 16, 1955).

At Panama during the period Jan. 13 to Feb. 17, 1955, nuclei were present in the atmosphere which caused the water drops to freeze at temperatures above those normally recorded; the abnormal nuclei were large and were also associated with abnormal rainfall. A similar phenomenon was observed in May and it is suggested that this is striking confirmation of Bowen's meteoritic hypothesis as both periods correspond with dates of meteoric showers [Abstr. 655 (1955)]. J. M. HOUGH

551.577.59

9293. A test for singularities in Sydney rainfall. E. J. Hannan. *Austral. J. Phys.*, **8**, *No.* 2, 289–97 (*June*, 1955).

A statistical test of the homogeneity of daily mean rainfalls (after the removal of a smooth seasonal trend) for Sydney over the years 1859 to 1952 does not contradict the hypothesis of homogeneity. The test was suggested by the theory that meteoric dust produces rainfall singularities, proposed by Bowen (1953). The test is made difficult by the complicated stochastic nature of the process generating the observations so that the significance level may in fact be lower than presumed. As the test statistic does not fall in the critical region, however, there can be no doubt that the test does not contradict the hypothesis (of homogeneity of means) at the presumed significance level. A.

551.577.59

9294. The fitting of truncated type III curves to daily rainfall data. S. C. Das. *Austral. J. Phys.*, **8**, *No.* 2, 298–304 (*June*, 1955).

The method of maximum likelihood has been used to fit a truncated type III (Gamma) distribution to daily rainfall data for Sydney over the period 1859 to 1952. An approximate test of the hypothesis that there is a singularity at the origin is suggested. This test is based on a comparison of the expected frequency in the truncated part, when the observed frequency in this part is taken into account in the fit, with the expected frequency when these observations are neglected. For Sydney the test shows that there is no evidence in the rainfall data for a singularity at the origin. A.

551.593

9295. Aerial blobs. F. Zwicky. *Science*, **122**, 159–60 (*July* 22, 1955).

These are volumes of air with linear dimensions varying from millimetres to many metres which have different optical properties from the surrounding air. These can be detected by the fact that stellar images are formed in a telescope in a plane other than the focal plane. J. M. HOUGH

551.593.5

9296. Optical installation for the study of atmospheric transparency. A. Arnulf, J. Bricard and C. Veret. *Rev. Opt.*, **33**, *No.* 12, 658–64 (*Dec.*, 1954) In French.

551.593.5

9297. A method for the integration of the radiative-transfer equation. G. N. Plass and D. I. Fivel. *J. Meteorol.*, **12**, *No.* 3, 191–200 (*June*, 1955).

The equations for radiative transfer are integrated exactly for a band of spectral lines which do not overlap and for an Elsasser band. The result of the two-fold integration of the absorption over frequency and over the atmospheric path can be expressed in terms of the Legendre functions. Here it is assumed that the mixing ratio is constant, that the line intensity is independent of temperature and that the Lorentz line shape is valid. Asymptotic forms of the Legendre functions are used to obtain the solutions to the following problems from these exact results. The regions of validity of the single-line and strong-line approximations are precisely stated. It is shown that the strongest line in the band absorbs more radiation than any other line in an atmospheric layer, when the overlap of the lines can be neglected. For an Elsasser band, an expression is derived for the line strength that gives the maximum absorption in an atmospheric layer for radiation emitted either by a black body at another level or by another atmospheric layer. A.

551.593.5

9298. The computation of infrared transmission by atmospheric water vapor. W. L. Godson. *J. Meteorol.*, **12**, *No.* 3, 272–84 (*June*, 1955).

A basic problem in atmospheric radiation is the computation of flux transmission (hemispheric radiation) for a narrow interval of the water-vapour spectrum. Individual lines are spaced more or less

at random and have widely divergent intensities. Even inside a narrow spectral interval, the line half-width and the variation of line intensity with temperature vary appreciably from line to line. With the assumption of a completely random line spacing, the above problem can be formulated rather simply for the limiting cases of thick layers and thin layers, even for an arbitrary atmosphere and spectrum. With the additional assumption of a logarithmic ogive for line intensities, a flux-transmission function can be developed, dependent on only two parameters, which gives reasonable accuracy over the entire transmission range. This accuracy can be further improved by semi-empirical corrections to the two basic parameters. If the requisite spectral parameters considered are known precisely, the method proposed should yield values of the flux divergence, as required for calculations of radiative heating and cooling, with relative errors of the order of 2 to 3%. Because these errors are largely random, the techniques can be applied with confidence in computations involving integrations over the entire spectrum. A.

551.593.61

9299. Anti-coronas or brocken bows. Y. G. NAIK AND R. M. JOSHI. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 733–6 (*Sept.*, 1955).

Brocken bows are sometimes observed in natural clouds as spectrum coloured rings surrounding the shadow of one's head. This phenomenon was reproduced in the laboratory by illuminating an artificial cloud produced by adiabatic expansion in a large cloud chamber. The light scattered in the backward direction by a cloud was observed by transverse reflection in a convex mirror kept in the path of a beam of light incident on the cloud. A reduced image of the shadow of the mirror on the cloud was seen surrounded by a series of spectrum coloured rings. About three to four orders of the rings of a given colour were often observed. The size of the rings of a given colour depends on the size of the water drops in the cloud. The size of the water drops in the cloud was determined by measuring the apertures of the diffraction rings (coronas) seen by transmitted light. It is found that in the case of Brocken rings $\alpha \sin\gamma_n = \pi(n - 1{\cdot}22)$, where $\alpha = 2\pi r/\lambda$, r being the radius of water drops, λ the wavelength of light, and γ_n the angular aperture of the nth-order bright ring. It is also shown that the size of drops in natural cloud in which Brocken bows are seen, should be near about $13{\cdot}5\,\mu$. A.

551.593.7

9300. Application of Chandrasekhar's theory to atmospheric polarization measurements. L. CASERTANO. *Geofis. pura appl.*, **30**, *No.* 1, 170–8 (1955) In Italian.

The average optical atmospheric thickness (τ) as a function of the meteorologic ground elements has been calculated, obtaining a result which shows its independence from those elements. The intensity of the radiations scattered by the atmosphere, as deduced from Chandrasekhar's theory for a given height of the sun and for every direction, being a function only of τ and of the albedo, it follows that these intensities are independent from the meteorologic conditions. Then it can be concluded that either the intensity of the light scattered by the air molecules does not depend upon the meteorologic factors or Chandrasekhar's theory, adequate for the computation of the effect of multiple scattering does not entirely represent the real phenomenon. Comparing the theoretic patterns for the polarization of sky-scattered light with the experimental data obtained in the Vesuvian Observatory, acceptable agreement has not been found, though, taking into account scattering of other than molecular origin, the second hypothesis seems more probable. A.

551.593.9

9301. The spectrum of the night sky in the red. I. Structure of the (6,1) band of the vibration-rotation system of the molecule OH. L. HERMAN AND R. HERMAN. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 13, 1413–14 (*March* 28, 1955) In French.

The spectral region 5700–6500 Å has been studied with the aid of a new spectrograph giving greatly increased resolution. Measured wavelengths of the (6,1) OH bands compare favourably with those calculated from laboratory data. The intensity of the bands is greatest at the beginning of the night.

G. M. BROWN

551.594.11

9302. Measurements of the electric potential gradient of the atmosphere. E. ALEXANDER, J. MARGONINSKY AND M. LEWIN. *Bull. Res. Coun. Israel*, **4**, *No.* 4, 341–6 (*March*, 1955).

Daily measurements of the atmospheric electric field and relative humidity made at ground level in Jerusalem Oct., 1952 to Dec., 1953 show that an increase of relative humidity is followed by an increase of potential and vice versa, particularly during khamsin conditions when both are exceptionally low. This is accounted for by the different radioactivity in damp air from the Mediterranean and very dry air from inland. Monthly averages show a potential increase in autumn and winter and a rapid fall in spring. No horizontal component of the electric field was detected. During thunderstorms the potential gradient reverses sign and a sudden sharp rise occurs. R. S. READ

551.594.12

9303. First investigation of ambient positive-ion composition to 219 km by rocket-borne spectrometer. C. Y. JOHNSON AND E. B. MEADOWS. *J. geophys. Res.*, **60**, *No.* 2, 193–203 (*June*, 1955).

The ambient positive-ion composition of the upper atmosphere in the range 8 to 49 atomic mass units (a.m.u.) was measured between 93 and 219 km by means of a Bennett radio-frequency mass spectrometer. The experiment was flown in the Navy Viking 10 rocket, launched from White Sands Proving Ground, Las Cruces, New Mexico, at $10^h\,00^m$ MST, May 7, 1954. The most prominent ion peaks found between 93 and 124 km on the ascent were at 16, 26, 30 and 32 a.m.u. Other less prominent peaks occurred at 12, 18, 19, 21, 23, 38 and 45 a.m.u. From 124 to 219 km, ions of 16 and 32 a.m.u. persisted. The results of this investigation are to be considered preliminary and need further verification, not only because the data were obtained from only

one flight, but also because of complications introduced by a charge acquired by the rocket and by the evolution of gas from the rocket. A.

551.594.14

9304. Evolution of atmospheric radioactivity in the Paris region. M. Abribat, J. Pouradier and A.-M. Venet. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 24, 2310–12 (*June* 13, 1955) In French.

Daily measurements of radioactivity have shown the passage of many atomic clouds, and particularly the series of explosions in U.S.A. and Russia, while those in the Pacific and Australia have been identified in Milan. For the Australian explosion in Oct., 1953 there was no radioactive increase in the air in the Paris region, while for the Pacific explosion there were measurable fluctuations but very feeble. For the Russian explosions in Aug., 1954 the fluctuations were much greater than for the Pacific ones. The radioactivity of atmospheric particles in 1954 has been much less than in 1953 and 1952. Measurements of the radioactivity of rain confirm the results obtained with dust particles. R. S. READ

551.594.14

9305. Variations of the natural and artificial radioactivity of the atmosphere. O. Tanaevsky and É. Vassy. *C.R. Acad. Sci.* [*Paris*] **241,** *No.* 1, 38–40 (*July* 4, 1955) In French.

Observations at Val Joyeux between Dec. 1953 and May 1955 show that the natural radioactivity decreases when the wind increases. Since Jan. 1955 the precipitation has been examined for radioactivity and the activity is not due to natural sources.

J. M. HOUGH

551.594.25

9306. The net electrification of natural cloud droplets at the earth's surface. W. L. Webb and R. Gunn. *J. Meteorol.*, **12,** *No.* 3, 211–14 (*June*, 1955).

Samples of more than 35 natural clouds passed through a special centrifuge and an ion filter in such a way that the free electricity on the droplets and on the air could be measured separately. The net charge on typical cloud droplets is less than one ion per droplet. This shows either that cloud droplets are not appreciably charged or that both positive and negative droplets are present and the distribution is such as to make the net charge very small. The measurements show that the capture of ions of a preferred sign by cloud droplets is not important. A.

551.594.5

9307. Photometry of the aurora. E. V. Ashburn. *J. geophys. Res.*, **60,** *No.* 2, 205–12 (*June*, 1955).

Simultaneous measurements of the 5577 Å line and the 3914 Å line in the aurorae are described. The measurements were made with a scanning photoelectric photometer. The 3914 Å line was present toward the north during the entire period of observation. The 3914 Å line usually showed a larger increase relative to the night-sky background than did the 5577 Å line. In a pulsating aurora, the 3914 Å line showed many small pulsations, whose period was 1 to 2 sec, in addition to the large pulsations. A.

551.594.5

9308. Diurnal variation in auroral activity. N. C. Gerson. *Proc. Phys. Soc. B*, **68,** *Pt* 7, 408–14 (*July*, 1955).

Analysis of three years' observation (1949–1951) of the ionized aurora indicate that it displays a marked diurnal distribution having a strong maximum at 2100 L.S.T. and having 86% of the total occurrences between 1700 and 2400 L.S.T. Auroral activity begins to increase between 1200 and 1500 L.S.T., attaining a nocturnal maximum about six hours later. The diurnal variation does not seem to be dependent upon geomagnetic control in the geomagnetic latitude interval 50–60° N. A.

551.594.5

9309. East-west motions in the aurora. R. C. Bless, C. W. Gartlein and D. S. Kimball. Note in *Astrophys. J.*, **122,** *No.* 1, 205–6 (*July*, 1955).

Analysis of 40000 ciné-frames of auroral forms photographed at Ithaca, U.S.A., since 1939, reveal the following facts regarding auroral movements. Of a total of 120 displays: 57 showed definite E- or W-motions; 35 exhibiting a dominant W-drift of rays, patches and draperies, and 22 an E-drift of these. A further 39 displays showed complex motion, including short-periods of alternating E–W movement. In only 8 displays was there a reversal of large-scale movement during the night; the time-reversal occurring between 10 p.m. and 2 a.m. local time.

D. R. BARBER

551.594.5

9310. Systematic auroral motions. A. B. Meinel. Note in *Astrophys. J.*, **122,** *No.* 1, 206–8 (*July*, 1955).

A reply to critical notes by McLaughlin (1954); Meek (1954); and Bless, Gartlein and Kimball (1953), regarding a publication by the author and Schulte [Abstr. 925 (1954)]. It is pointed out that the emphasis was not upon an exact, or detailed relationship of the space-time configuration of aurorae; but on a systematic tendency for a W–E drift to occur during the second-half of the night. This phenomenon bears a striking resemblance to the reversal of the ionospheric current near noon and midnight, during geomagnetic storms. D. R. BARBER

551.594.6 : 621.396.81

9311. Thunderstorm signals at very-high frequency and ultra-high frequency. D. R. Hay and T. R. Hartz. Letter in *Nature* [*London*] **175,** 949–50 (*May* 28, 1955).

During monitoring proceedings thunderstorm signals were recorded on 4 receivers operating at 49, 91, 173 and 492 Mc/s. These records should offer a comparison of the relative amplitudes over a wide frequency range. R. H. Golde (R)

BIOLOGY 57/59

MEDICAL SCIENCE . HUMAN PHYSIOLOGY 61

612.014.482 : 539.172.4

9312. The radiological dose to persons in the U.K. due to debris from nuclear test explosions. N. G. STEWART, R. N. CROOKS AND E. M. R. FISHER. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. HP/R*1701, 20 *pp.* (1955).

612.014.482 : 539.166.08

9313. Assay of γ-radiation from the human body. P. R. J. BURCH AND D. B. APPLEBY. *Atomics* [*London*] **6**, *No.* 7, 195–201 (*July*, 1955).

See also Abstr 729 (1954). The subject lies on a stretcher beneath four large ionization chambers (14 atm.N_2) and the background ion current is balanced against that from seven other chambers. The average of the resultant current over many hours is determined by a uniselector circuit operated automatically from the electrometer and recorder. The circuit operation is explained and discrimination is provided against large fluctuations arising from cosmic-ray bursts. It is pointed out that when normal body activity (K^{40} + trace Ra) is increased with accidental intake of radium it is necessary to measure exhaled radon and with intake of two isotopes a measurement of radiation quality is needed.

J. R. MALLARD

612.843

9314. The influence of a mydriatic on the Stiles–Crawford effect. L. RONCHI. Letter in *Optica Acta*, **2**, *No.* 1, 47–9 (*April*, 1955) In French.

When a 2% solution of β-phenyl-isopropylamine sulphate is instilled into the eye the Stiles–Crawford effect is found to be reduced maximally about 50 min after the instillation. R. A. WEALE

612.843.31

9315. Some quantitative aspects of an opponent-colors theory. II. Brightness, saturation, and hue in normal and dichromatic vision. L. M. HURVICH AND D. JAMESON. *J. Opt. Soc. Amer.*, **45**, *No.* 8, 602–16 (*Aug.*, 1955).

For Pt I, see Abstr. 7570 (1955). A quantitative model for an opponent-colours theory of vision is presented that is based on the C.I.E. colour mixture data for the standard observer. The model is used to account for spectral brightness, saturation and hue, and some of their associated psychophysical functions in both normal and dichromatic vision. Special attention is given to an account of the Bezold–Brücke hue shift, and to changes in saturation and wavelength discrimination with changes in stimulus luminance. A.

612.843.37

9316. Spectral sensitivity of the eye in conditions of twilight adaptation. S. G. YUROV. *Svetotekhnika, No.* 1, 12–14 (1955) In Russian.

Numerical values are given of spectral sensitivity for five different levels of adaptation of the eye averaged for two observers. W. R. STOKER

612.843.37

9317. Application of S. I. Vavilov's method to the determination of rod spectral sensitivity of the eye. R. L. FOL'B. *Svetotekhnika, No.* 1, 15–18 (1955) In Russian.

Curves of spectral sensitivity corresponding to darkness adaptation of the eye are given and are in good agreement with values obtained by a different method by Hurvich and Jameson [see Abstr. 5818 (1953)]. W. R. STOKER

612.843.611

9318. Course of dark adaptation under various conditions of pre-exposure and testing. E. WOLF AND M. J. ZIGLER. *J. Opt. Soc. Amer.*, **45**, *No.* 9, 696–702 (*Sept.*, 1955).

Dark adaptation curves are obtained by presenting a 2° square testfield 6° below the centre of the fovea for both eyes tested separately and for both eyes tested alternately. When the pre-exposure luminances for the two eyes differ, the independently recorded dark adaptation curves for the two eyes show differences in correspondence with the difference in radiant energy delivered to the eyes during pre-exposure. However, if both eyes are pre-exposed simultaneously to their respective luminances, and are alternately tested, the dark adaptation curves are not identical with those previously found. They move closer together, or coincide, i.e. the differences in threshold sensitivity become smaller, or disappear. When pre-exposure of the two eyes differs merely in admitting the near ultraviolet (285–400 mμ) to one eye, and screening it from the other, the curves independently recorded for the two eyes have different threshold levels, but in alternate testing no difference is found. It is also shown that an influence of the near ultraviolet upon visual thresholds is readily found when white and blue testlights are employed; it is barely evident when a green testlight is used and is not found with a red testlight. A.

612.85

9319. Effect of delayed acoustic feedback on some non-vocal activities. H. KALMUS, P. DENES AND D. B. FRY. Letter in *Nature* [*London*] **175**, 1078 (*June* 18, 1955).

It is now well known that difficulties in speaking will result if the speaker is made to listen to the sound of his own voice delayed by about 0·1 to 0·3 sec. This delayed feedback will produce stuttering, reduced rate of speaking, distortion of sound quality and other impairments of speech. The authors now demonstrate that delayed acoustic feed-back can affect other, non-vocal activities—e.g. in the clapping of hands. The subject was asked to clap his hands as regularly as possible six times following each click of a metronome. With no acoustic delay this was accomplished easily, but when a delay of, say, 0·25 sec was introduced the hands often clapped seven times instead of six and at other times clapping ceased altogether after alternate clicks. Sometimes subjects were aware of their mistakes but in other cases they were not. It is considered that the study of this

variation of response promises some insight into individual development and possibly into the genetics of certain faculties concerned with rhythm and counting.

A. B. WOOD

612.85

9320. Addition to Cherry's findings on switching speech between the two ears. E. D. SCHUBERT AND C. D. PARKER. *J. Acoust. Soc. Amer.*, **27**, *No.* 4, 792–4 (*July*, 1955).

The authors repeated the experiments of Cherry and Taylor [Abstr. 9862 (1954)] with similar results apart from a less marked reduction in intelligibility at the critical switching rate (4 c/s). In a second set of experiments the ear not receiving speech was fed with random noise. In this case the dip in intelligibility tended to disappear. Possible explanations are discussed.

J. M. C. DUKES

612.85 : 534.3

9321. The musician as a guinea pig. A. G. PIKLER. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 3, 617 (*May*, 1955).

M. F. Meyer [Abstr. 669 (1955)] confronted the reliability of physiological experiments on anaesthetized animals with that of conscious human hearing, whereas the author in his critical assessment stresses the competence of the musician's absolute pitch (identification of acoustic frequencies) and internal pitch (soundless acoustic reproduction in mind). And yet, it is not the musician who is subjected to such psychoacoustic tests of reliability. Consequently, the problem arises whether there are two distinct types of auditory mechanisms, one to be ascribed to "normal" and the other to "musical" hearing as an exception.

J. C. STARK

612.858.71

9322. Note on the threshold of pulsed signals as a function of duty cycle and carrier frequency. A. M. SMALL, JR. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 4, 794 (*July*, 1955).

A series of experimental curves are shown in which the sound pressure level required to elicit a threshold response is plotted as a function of the "duty cycle" (fraction of total time used in transmission of pulses), with the carrier frequency (1 000 to 8 000 c/s) of the pulsed tone as a parameter. The repetition rate of the tone pulses was 100 p.p.s. All the curves have a similar form, the threshold pressure declining rapidly at first, levelling off and then declining again. The final duty cycle of 1·0 of course represents a continuous signal. The author discusses the significance of his observations in relation to similar work by W. R. Garner [Abstr. 3757 (1947)].

A. B. WOOD

612.858.751

9323. Monaural direction finding. R. C. MATHES. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 4, 792 (*July*, 1955).

Refers to some simple experiments made during temporary deafness of one ear. Direction finding was quite random for a pure tone source, but fairly successful with "clicks." In the latter case a change of quality with direction due to the differential shadowing effect of the head. The effects appear to be basically similar to those reported by J. C. Mouzon [Abstr. 5293 (1955)].

A. B. WOOD

616–073.7

9324. The electric field of the heart. Electrocardiographic technique. RAOULT. *Bull. Soc. Franç. Elect.* (*Sér.* 7) **5**, 172–8 (*March*, 1955) In French.

The E.C.G. waveform is discussed in terms of an "electric shell" at the position of the heart with varying polarization and producing a changing field at the body surface.

F. T. FARMER

TECHNIQUE. MATERIALS 62/69

666

9325. Absorption of carbon dioxide gas in fused glass. J. MAHIEUX. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 26, 2521–2 (*June* 27, 1955) In French.

The absorption of CO_2 in fused glass has been studied by using CO_2 labelled with C^{14}. It was found that, in an atmosphere where the partial pressure of CO_2 was 1% of the total pressure, the mass of CO_2 absorbed per gram of glass (% composition: $Na_2O = 14$, $CaO = 29$, $SiO_2 = 57$) was 78×10^{-3}, 70×10^{-3}, 42×10^{-3} mg at 1 108, 1 212 and 1 315°c respectively.

J. IBALL

PHOTOGRAPHY 77

771.534

9326. A measurement of Schwarzchild's constant. A. H. TURNBULL. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. GP/R*1695, 1 *p.* (1955).

The report describes a simple method of measuring Schwarzchild's constant for a photographic emulsion.

A.

771.534.5 : 537.531

9327. On the mechanism of the photographic action of X-rays. J. MALINOWSKI. *Z. phys. Chem.* [*Leipzig*] **204**, *No.* 5–6, 276–85 (*Aug.*, 1955).

It is shown that the mean energy ε_0 which an emulsion grain ought to absorb in order to become developable can be determined from sensitometric data. The values obtained in this way for several commercial emulsions, exposed to X-radiation of effective wavelength 0·12 Å, show that ε_0 is of the same order of magnitude for all emulsions investigated, in spite of their wide difference in light sensitivity and specification. The experimental results indicate further that ε_0 is greater for the coarser grained emulsions, increasing approximately proportionally to the third root of the average mass of the emulsion grains. The dependence of ε_0 on the geometrical dimensions of the emulsion grains, and not on their sensitivity towards light, is explained in view of the experimental evidence that the latent image formed by X-rays is found to be dispersed throughout the entire volume of the emulsion grains.

A.

771.535

9328. Topography of the latent image. E. SCHOPPER, S. MAGUN AND W. BRAUN. *Royal Photographic Society International Conference* [*London*] 122–7. See Abstr. 7586 (1955).

The effects of double-exposure (Herschel, Clayden, Sabattier effect) are of characteristically different behaviour with light-sensitive and with nuclear-track emulsions. Their comparison under different methods of development leads to conclusions on the topography of the latent image. A.

771.535

9329. The localization and nature of the latent image produced by different types of radiation in several types of emulsion. P. CÜER AND R. SCHMITT. *Royal Photographic Society International Conference* [*London*] 128–34. See Abstr. 7586 (1955).

The experiments by Cüer and Desprez [*Science et Industries Photographique*, **21**, *No.* 5, 161 (1950)] are repeated and extended quantitatively with nuclear emulsions, and some ordinary emulsions. A detailed analysis of the sensitometric curves obtained with a photomultiplier microphotometer shows that the images produced by various radiations (α, β, γ, light) in thin nuclear emulsions behave identically. The image was attacked by various agents (hydrogen peroxide, chromic acid, etc.), then treated with different types of developers (solvent and non-solvent). A study of the Herschel effect on the principal types of nuclear emulsions allows an interpretation of the apparently contradictory results of Schopper and collaborators, Goldstein and Sherman, and Winand. The results are applied to practical problems of discriminating between various corpuscles. It is found that the Herschel effect associated with low pH developers allows a clear-cut discrimination between light and particle latent images. Results are tentatively interpreted in terms of a dispersed latent image in the case of particles. A.

771.535 : 537.531

9330. The photographic effect of X-rays. The influence of the range of primary or secondary electrons and of the volume of the grains. H. TELLEZ-PLASENCIA. *Royal Photographic Society International Conference* [*London*] 117–21. See Abstr. 7586 (1955).

In an earlier paper [*Science et Industries Photographique*, **24**, *No.* 2, 1–21 (*Jan.*, 1953)] experiments were described in which emulsions of nearly identical composition but of varying grain-size had been exposed to increasing X-ray irradiations. In principle the coefficient of the relation of "co-density" logarithm and fraction of the absorbed energy which was transformed into electronic work should be constant, but it was found that in reality it varies with the wavelength of the radiation in the case of fine-grain emulsions, and with the exposure in the case of coarse-grained emulsions. It is logical to attribute these effects (especially the first) to the fact that the energy consumed had been calculated taking into account mechanisms of absorption and of production of primary and secondary electrons, but neglecting the heterogeneity of the emulsions and the fact that part of the electron energy gets lost in the gelatin without any useful effect. A new approximation can be obtained by calculating either (*a*) that part of the energy which was imparted by the electrons to the silver–bromide grains alone as a function of their total path, or (*b*) the number of grains hit by electrons detached at different levels by photons of a given energy. Instead of obtaining a function of energy yield which depends only on the wavelength and on the silver bromide content of the emulsion, one obtains under these conditions another function which varies also with the grain-size. The differences between different emulsions seem to correspond to experimental differences. A.

772

9331. Some experiments on pressure effects in photographic emulsions. E. A. BRAUN AND D. NAHSHOL. Letter in *Bull. Res. Coun. Israel*, **4**, *No.* 4, 394–5 (*March*, 1955).

Static pressure applied during exposure does not affect the total density obtained, but the external latent image is reduced at the expense of the internal. This is probably due to increase of internal dislocations on which Ag nuclei can be formed.

S. T. HENDERSON

778.33

9332. Photographic images for resolution testing in radiography. E. T. SMITH AND G. W. W. STEVENS. *Royal Photographic Society International Conference* [*London*] 412–16. See Abstr. 7586 (1955).

Photographic resolution test images which are sufficiently opaque to X-rays to enable them to be used for resolution testing in radiography have been made by using a mercury physical developer to intensify images produced by Maximum Resolution plates. The extremely fine grain of the originally developed image permits a very great intensification to be obtained, so that the mercury in the final image may be equivalent to fifty times the silver content of the untreated emulsion. The use of the charts in different fields of radiography is discussed, and some preliminary results are given. A.

778.33

9333. Factors affecting resolution in autoradiography. L. F. LAMERTON AND E. B. HARRISS. *Royal Photographic Society International Conference* [*London*] 417–22. See Abstr. 7586 (1955).

The aim of autoradiography is to obtain information on the distribution of radioactive material within a specimen from the image produced when the specimen is placed in contact with a photographic emulsion. Various autoradiographic techniques, differing in resolution and in sensitivity, are now available, each having its own particular field of usefulness. Certain aspects of the resolution problem in autoradiography are discussed, including the effect of improving contact between specimen and emulsion. A modification of the definition for resolution is proposed. Factors limiting the attainment of high resolution are discussed, including that of the "cross-fire" of radiation from other parts of the specimen. Examples of autoradiographs to illustrate various points are given. A.

778.33

9334. On the radiographic and radiometric surface-analysis of light metal alloys. W. BRAUN. *Z. angew. Phys.*, 7, *No.* 9, 427–33 (1955) In German.

A survey of the use of autoradiographic methods

with a discussion of the principles and techniques of the use of tracers, neutron and charged-particle activation, radiochemical activation and the photography of particle tracks. A second paper on X-ray reflection radiography is to follow. J. THEWLIS

778.33 : 539.16

9335. Thulium 170 for industrial radiography. K. LIDÉN AND N. STARFELT; R. HALMSHAW. Letter in *Brit. J. appl. Phys.*, **6**, *No.* 7, 262 (*July*, 1955).

Corrects a statement in a paper of the same title by Halmshaw [Abstr. 1430 (1955)] that "The exact nature of the γ-ray spectrum does not appear to be agreed . . .", by citing two references to more recent work. A brief acknowledgment and comment by Halmshaw is appended. J. HUGHES

778.33 : 539.165

9336. On the quantitative relation between isotopic beta radiation and its photographic response. R. K. PODDAR. *Indian J. Phys.*, **29**, *No.* 4, 189–98 (*April*, 1955).

The photographic action of the continuous beta spectrum as emitted by the radioisotopes has been studied. It has been deduced theoretically that the optical density, D, produced by the beta particles in any photographic emulsion should approximately vary, directly as the number, Q, of the beta particles striking it per unit area and inversely as the average energy, E, of the beta spectrum of the isotope concerned, *i.e.*, in short, $(D \times Q)/E \simeq$ a constant. This relation has been experimentally verified in the case of Au^{198}, I^{131} and P^{32}, three isotopes frequently used in biophysical investigations. It has also been found that the values of the number of beta particles/cm^2 necessary to produce a density of 0·6 above background in the photographic emulsion used are $2{\cdot}8 \times 10^8$, $1{\cdot}7 \times 10^8$ and $6{\cdot}5 \times 10^8$, respectively in the case of Au^{198}, I^{131} and P^{32}. A.

778.34

9337. A contribution to the study of development and corrosion in nuclear emulsions. G. MEULEMANS. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 410–11 (1954) In French.

Measurements have been made of the optical density and of the number of grains at minimum ionization for nuclear emulsions developed in three developers containing respectively 0·5, 1·0 and 4·5 g/litre of amidol. The time of development was varied between 1 and 3 hours and the temperature of the hot bath between 15 and 27°c. The results are presented graphically. Several errors that appeared in the report of the Bagnères Conference (p. 61, 1953) concerning corrosion during fixing are corrected.

P. ROTHWELL

778.34

9338. The effect of the finite thickness of the emulsion layer in studying nuclear processes by the photographic method. A. A. BENE AND M. M. AGREST. *Zh. éksper. teor. Fiz.*, **27**, *No.* 5(11) 557–62 (1954) In Russian.

General expressions are worked out for the escape correction, and a graph given for the reaction $Li^6(n,\alpha)H^3$ for emulsion thicknesses between 50 and 200 μ. J. HUGHES

778.34

9339. Grain counting in groups in nuclear emulsions. I. IORI AND A. ROVERI. Letter in *Nuovo Cimento* (*Ser.* 10) **2**, No. 1, 165–7 (*July*, 1955) In Italian.

In the study of fluctuations in single or group grain counting along the tracks of ionizing particles in nuclear emulsions, the formula for the mean square differences, calculated according to Bernoulli statistics, has been checked experimentally, for a cell length of 50 μm. Curves showing the variation of mean square difference with number of grains per cell, for different values of the mean diameter of the grain developed, give satisfactory agreement between experimental values and Bernoulli statistics. Poisson statistics do not fit with the experimental points.

P. ROTHWELL

778.34

9340. Theory of tracks in nuclear research emulsions. J. M. BLATT. *Austral. J. Phys.*, **8**, *No.* 2, 248–72 (*June*, 1955).

The process of the formation of a visible track in a nuclear research emulsion is approximated by a simplified model which reduces it to a one-dimensional problem. Within this basic approximation, there are included many different detailed models, including all models so far proposed in the literature. The following quantities characteristic of the track are then considered: the number of gaps longer than some minimum length r contained in a cell length t of the track, $n_r(t)$; and the sum of the excess (over and above r) lengths of these n_r gaps, $x_r(t)$. Complete theoretical results are derived for the mean values and standard deviations of these quantities, in terms of a small number of definite integrals. Particular detailed models are then considered, and a quick comparison against experiment is made. The model of O'Ceallaigh fails to agree with experimental data, and so do all straightforward generalizations of that model, such as the model of Happ, Hull and Morrish. The reason for this failure is traced to the neglect of the "graininess" of the emulsion before development. The model of Herz, which takes the extreme opposite point of view, comes much closer to fitting the data. A reasonable modification of the Herz model is also given. A more detailed comparison against experiment must still be made. A.

778.34

9341. On the measurement of ionization in nuclear plates. C. CASTAGNOLI, G. CORTINI AND A. MANFREDINI. *Nuovo Cimento* (*Ser.* 10) **2**, *No.* 2, 301–13 (*Aug.*, 1955).

Using an apparatus previously described [Abstr. 7595 (1955)], measurements of the number of gaps $\bar{n}$, total length of gaps $\bar{x}$, mean gap length $\bar{w} = \bar{x}/\bar{n}$, and number of "long" gaps $\bar{n}_\epsilon$, were made on a large number of tracks. Proton, π-meson and μ-meson tracks coming to rest in the stack of emulsions (Sardinian Expedition 1953) were employed. A rather large velocity interval has been investigated ($0 < v/c < 0{\cdot}80$). The experimental results are compared with the different theories which have been proposed to describe the formation of tracks of ionizing particles in nuclear emulsions. The problem of choosing the parameter which must be measured in the different velocity intervals in order to obtain

the best value of the mass is discussed. The best parameters are found to be: in the near minimum region $\bar{w}$, and in the "clogged" region $\bar{x}$. A.

778.34

9342. A simple method of determining the shrinkage factor of nuclear research emulsions. P. J. DUKE, W. O. LOCK, P. V. MARCH AND B. A. MUNIR. Letter in *J. sci. Instrum.*, **32**, *No.* 9, 365 (*Sept.*, 1955).

Immediately after exposure the total thickness of the glass-backed emulsion is measured at a central point by a micrometer reading to $\frac{1}{4}\mu$. After processing the thickness is measured again in the same place. The shrinkage is thus obtained directly. The thickness of the emulsion is then measured at several points with a microscope calibrated with slip gauges. The original thickness is then known independently from any changes in humidity. The shrinkage factor is always determined at the time of observation by measuring the thickness of the emulsion at the same point. From a single batch of emulsions the factor is found to vary from 2·46 to 2·52 at a relative humidity of 60%. The values obtained for the original thickness varied from 396 to 421μ.

D. J. PROWSE

778.34

9343. Arrangement for precise scattering measurements in nuclear emulsions. W. STODIEK. *Nuovo Cimento* (*Ser.* 10) **2**, *No.* 3, 467–70 (*Sept.*, 1955).

An arrangement is described whereby, employing a simple microscope, the magnitude of the stage noise is reduced, independent of the cell length, so that it does not influence the determination of the scattering angle. The insensitivity to shock or vibration permits the use of a screw micrometer eye-piece. An auxiliary device for convenient alignment of the nuclear plates is also described. A.

778.34 : 537.534.74

Detection of polarization of beams of fast particles by means of nuclear photo-emulsions. *See Abstr.* 8846

778.34 : 539.172.13

Abacus for simplifying the calculations of neutron energy in (*d*, *n*) reactions. *See Abstr.* 9085

778.34 : 539.172.4

Escape fraction of recoil protons caused by incident neutrons in photographic plates. *See Abstr.* 9104

778.34 : 539.185.08

Measurements of neutronic dose by means of photographic plates. *See Abstr.* 9162

778.37

9344. Investigation of very fast light processes. E. K. ZAVOĬSKIĬ AND S. D. FANCHENKO. *Dokl. Akad. Nauk SSSR*, **100**, *No.* 4, 661–3 (1955) In Russian.

Describes the high-frequency modification of Courtney–Pratt's method [Abstr. 644 (1950)] for photographing details occurring within 10^{-12}–10^{-13} sec. Short electric sparks (spark gaps of 0·02–0·10 mm in a vibrator, and 0·2–1 mm in a condenser; atmosphere of N under 10–30 atm. or atmospheric air) were photographed, using a sufficiently sensitive image convertor and a generator, the wavelength range being 95–150 cm. It was found that, in N at 10 atm., the dimension of the zone of bright luminescence did not exceed 10μ, while the luminescence period of the excited atoms, molecules or ions in this zone did not exceed 1×10^{-11} sec. The degree of time resolution in this research was determined by microphotometry of the spark image on the film. The variations of blackening could be reliably determined for lengths corresponding with time intervals down to 3×10^{-12} sec. It is claimed that the ultra-high-frequency method of image conversion can also be used for studying such phenomena as luminescence and Cherenkov's radiation.

F. LACHMAN

778.37

9345. A short duration, double-flash system for simultaneous or delayed operation. N. DOMBROWSKI, R. P. FRASER and G. T. PECK. *J. sci. Instrum.*, **32**, *No.* 9, 329–31 (*Sept.*, 1955).

An account is given of the development of an apparatus employing two separate flash discharge tubes operated either simultaneously or consecutively with a means to vary the interval from 0·01 to 10 msec. The two sources of an energy of 5 J are designed for a flash duration of 6 μsec at 10% of peak light. An example is given of the application of the apparatus to the study of the mechanics of spray nozzles. A.

778.37 : 621.383

9346. Millimicrosecond exposures by image tubes. R. F. SAXE AND R. A. CHIPPENDALE. *Brit. J. appl. Phys.*, **6**, *No.* 9, 336–8 (*Sept.*, 1955).

The technique whereby an image tube and a coaxial system may be used to obtain pictures with an exposure not exceeding 4 mμsec is described. Pictures showing the growth of a streamer across a gap in approximately 4 mμsec are given. The limitations of this technique are briefly discussed, and it is estimated that exposures of the order of 10^{-10} sec should be possible. A.

778.37 : 621.383.6

9347. Kerr cell shutter has submicrosecond speeds. W. Q. NICHOLSON AND I. ROSS. *Electronics*, **28**, *No.* 6, 171–3 (*June*, 1955).

The shutter with an effective aperture of *f*/7 and a view angle of 20° is operated at a speed of 0·1 μsec by means of a narrow 45 kV pulse from a network-transformer combination. The cell operation can be checked by means of a pulse at 60 p.p.m. and a synchroscope. G. HOWELLS (R)

778.5

9348. One million frame per second camera. B. BRIXNER. *J. Opt. Soc. Amer.*, **45**, *No.* 10, 876–80 (*Oct.*, 1955).

The design and construction of a rotating mirror frame camera is described. Twenty-five consecutive pictures 20 mm in diameter can be obtained on a strip of 35 mm film. A resolution of at least 20 lines/mm is obtained on a moderately fast film. Accurate synchronization of the event to be photographed is required. The camera has been most useful in the investigation of explosive and related phenomena. A.